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ABSTRACT

These instructional units, developed in Oklahoma, are designed for training power line technicians for rural electric cooperatives. Planned to help current employees advance in knowledge and skill, the instructional materials are divided into seven areas of training: Laborer; Groundworker or Equipment Operator; Power Line Technician, Step 1; Power Line Technician, Step 2; Power Line Technician, Step 3; Power Line Technician, Step 4; and Journey Line Technician. Each area includes three to nine instructional units. Each unit contains a unit objective, specific objectives, suggested activities, information sheet, test and test answers, and suggested activities. A list of references used in preparing the instructional materials is included. (KC)

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Power Line Technician's Training

Instructional Units

Earle L. Smith
Curriculum Writer

Developed by the
Curriculum and Instructional Materials Center
In cooperation with the
Rural Electric Cooperatives of Oklahoma
Oklahoma State Board of Vocational and Technical Education
Leslie Fisher, Chairman
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Materials Center
1978

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FOREWORD

Another first has come to the Rural Electric Cooperatives - a training program for existing employees within the cooperatives in Oklahoma. The Oklahoma Association of Rural Electric Cooperatives and the Oklahoma State Department of Vocational and Technical Education have joined efforts to develop instructional materials for the training of power line technicians.

These past few months have been trying times for most cooperatives in Oklahoma. The cost of producing electricity for our consumers has increased tremendously. In order for the cooperatives to stay financially sound and still be able to deliver economical electrical power to our customers, we must have a highly skilled group of employees. *Power Line Technician's Training* has been developed in such a way that it should fit most cooperatives' training programs. The instructional materials are divided into seven areas of training: Laborer; Groundworker or Equipment Operator; Power Line Technician, Step I; Power Line Technician, Step II; Power Line Technician, Step III; Power Line Technician, Step IV; and Journey Power Line Technician.

With the acceptance and implementation of these instructional materials, a higher degree of skilled performance will be achieved at the cooperative level. Let's get behind this training effort and make our dream become a reality.

D. J. "Duke" Cooper, Manager
Central Rural Electric Cooperative

PREFACE

The importance of providing every student enrolled in a power line technician's training program with the best and most complete basic training possible cannot be overemphasized. This publication was developed with the intent of providing the basic skills and knowledge that the student will need as a foundation from which to build.

Power Line Technician's Training was developed with the assistance of many individuals knowledgeable in the profession. Their assistance and devotion to the project is greatly appreciated. This publication, coupled with the instructor's and student's attitude of "professionalism", can become a vital part of the teaching-learning process.

Every effort has been made to make this publication basic, readable, and usable in an ever-growing field of power transmissions and distribution.

Earle L. Smith
Curriculum Writer

ACKNOWLEDGMENTS

Appreciation is expressed to the many individuals who gave their time and knowledge in the preparation of this manual. Without their assistance, this publication would not have been possible.

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(NOTE: This an alphabetized list of the publications used in completing this manual.)

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ORIENTATION TO REC
UNIT I

UNIT OBJECTIVE

After completion of this unit, the student should be able to discuss the importance of rural electric cooperatives and describe how they benefit rural America. This knowledge will be evidenced by scoring 85 percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms associated with REC orientation to the correct definitions.
2. State the reason for establishing the Rural Electrification Administration.
3. Discuss the importance of rural electric cooperatives.
4. Describe the benefits of rural electric cooperatives to rural America.
5. Select from a list the finance agencies which loan money to rural electric cooperatives.
6. List types of electric utilities.

ORIENTATION TO REC
UNIT I

SUGGESTED ACTIVITIES

I. Suggested activities for instructor:

   A. Provide student with objective sheet.

   B. Provide student with information sheet.

   C. Discuss unit and specific objectives.

   D. Discuss information sheet.

   E. Give test.

II. Unit references:

   A. *Oklahoma's REC's: Consumers in Action.* Pamphlet. Oklahoma City: Oklahoma Association of Electric Cooperatives, 1976.

   B. Cooper, Donald H., ed. *Rural Electric Facts: American Success Story.* Washington, D.C.: National Rural Electric Cooperative Association, 1970.

ORIENTATION TO REC
UNIT I

INFORMATION SHEET

I. Terms and definitions

   A. Rural electric cooperative (REC)--Private nonprofit corporation owned and operated by its consumer-members

   B. Rural Electrification Administration (REA)--Finance agency which serves as a banker and makes technical advice available but does not build, own, or operate any electrical facility

   C. Cooperative Finance Corporation (CFC)--Finance agency which provides supplemental financing for its member rural electric systems

   D. Investor-owned electric utility--Utility owned by stockholders

   E. Municipal electric utility--Utility owned by the city it serves

   F. Federal- or state-owned utility--Transmission and generation utility owned by the state or federal government

II. Reason for establishing Rural Electrification Administration--To assist rural Americans in acquiring electrical service at a rate comparable to that of urban Americans

III. Importance of rural electric cooperatives

   A. Economic value

   (NOTE: The cooperatives have a multi-million dollar payroll in Oklahoma alone.)

   B. Electric appliance market

   (NOTE: A multi-million dollar sales market has been created by rural electricity.)

   C. Increased production

   (NOTE: Electric-driven systems have significantly increased production in manufacturing and services.)

   D. Recreational areas

   (NOTE: Light and power in remote locations have made lakeside cabins and park areas good recreational sites.)

INFORMATION SHEET

IV. Benefits of RECs to rural America

  A. Dependable electrical service to cook, heat, cool, and do many chores which previously had to be done by hand

  B. Modern water and plumbing systems made possible by electric water pumps

  C. Communications through radio, television, and citizen's band two-way radios

  D. Rural standard of living equal to that of urban dwellers

V. Agencies which loan money to RECs

  A. Rural Electrification Administration

  B. Cooperative Finance Corporation

  C. Banks for Cooperatives

VI. Types of electric utilities

  A. Rural electric cooperative

  B. Municipal

  C. Investor-owned

  D. Federal- or state-owned

ORIENTATION TO REC
UNIT I

TEST

NAME ______________________________ SCORE ______________

1. Match the terms on the right to the correct definitions.

_____a. Utility owned by stockholders

_____b. Finance agency which serves as a banker and makes technical advice available but does not build, own, or operate any electrical facility

_____c. Finance agency which provides supplemental financing for its member rural electric systems

_____d. Private nonprofit corporation owned and operated by its consumer-members

_____e. Utility owned by the city it serves

_____f. Transmission and generation utility owned by the state or federal government

1. Rural electric cooperative (REC)
2. Investor-owned electric utility
3. Rural Electrification Administration (REA)
4. Cooperative Finance Corporation (CFC)
5. Federal- or state-owned utility
6. Municipal electric utility

2. State the reason for establishing the Rural Electrification Administration.

____

____

3. Discuss the importance of rural electric cooperatives.

____

____

____

____

4. Describe the benefits of rural electric cooperatives to rural America.

____

____

____

____

____

5. Select from the list below the finance agencies which loan money to rural electric cooperatives by placing an "X" in the blanks provided.

______a. Small Business Administration

______b. Cooperative Finance Corporation

______c. Grand River Dam Authority

______d. Rural Electrification Administration

______e. First National Bank and Trust

______f. Banks for Cooperatives

6. List two types of electric utilities.

a. ____

b. ____

ORIENTATION TO REC
UNIT I

ANSWERS TO TEST

1. Match the terms on the right to the correct definitions.

   2 a. Utility owned by stockholders

   3 b. Finance agency which serves as a banker and makes technical advice available but does not build, own, or operate any electrical facility

   4 c. Finance agency which provides supplemental financing for its member rural electric systems

   1 d. Private nonprofit corporation owned and operated by its consumer-members

   6 e. Utility owned by the city it serves

   5 f. Transmission and generation utility owned by the state or federal government

   1. Rural electric cooperative (REC)
   2. Investor-owned electric utility
   3. Rural Electrification Administration (REA)
   4. Cooperative Finance Corporation (CFC)
   5. Federal- or state-owned utility
   6. Municipal electric utility

2. State the reason for establishing the Rural Electrification Administration.

   To assist rural Americans in acquiring electrical service at a rate comparable to that of urban Americans

3. Discuss the importance of rural electric cooperatives.

   a. Economic value

   b. Electric appliance market

   c. Increased production

   d. Recreational areas

4. Describe the benefits of rural electric cooperatives to rural America.

   a. Dependable electrical service to cook, heat, cool, and do many chores which previously had to be done by hand

   b. Modern water and plumbing systems made possible by electric water pumps

c. Communications through radio, television, and citizen's band two-way radios

d. Rural standard of living equal to that of urban dwellers

5. Select from the list below the finance agencies which loan money to rural electric cooperatives by placing an "X" in the blanks provided.

____a. Small Business Administration

_X_b. Cooperative Finance Corporation

____c. Grand River Dam Authority

_X_d. Rural Electrification Administration

____e. First National Bank and Trust

_X_f. Banks for Cooperatives

6. List two types of electric utilities.

(NOTE: Any two of the following are acceptable.)

a. Rural electric cooperative

b. Municipal

c. Investor-owned

d. Federal- or state-owned

INTRODUCTION TO POWER LINE TECHNICIAN'S TRAINING
UNIT II

UNIT OBJECTIVE

After completion of this unit, the student should be able to select from a list responsibilities of a line technician to the community and employer and list benefits from the line technician's training program. This knowledge will be evidenced by scoring eighty-five percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. List responsibilities of a line technician to the community.
2. Select from a list the responsibilities of a line technician to the employer.
3. Select from a list information that is shown on an organizational chart.
4. List departmental functions of a line department.
5. Select from a list topics taught in this course.
6. List benefits to students who complete this line technician's training course.

INTRODUCTION TO POWER LINE TECHNICIAN'S TRAINING
UNIT II

SUGGESTED ACTIVITIES

I. Suggested activities for instructor:

   A. Provide student with objective sheet.

   B. Provide student with information sheet.

   C. Make transparency.

   D. Discuss unit and specific objectives.

   E. Discuss information sheet.

   F. Give test.

II. Unit reference--Cooper, Donald H., ed. *Rural Electric Facts: American Success Story*. Washington, D.C.: National Rural Electric Cooperative Association, 1970.

INTRODUCTION TO POWER LINE TECHNICIAN'S TRAINING
UNIT II

INFORMATION SHEET

I. Responsibilities of a line technician to community

   A. Participate in civic organizations, business clubs, churches, and political parties

      (NOTE: The line technician who participates in the Jaycees, Lions, Kiwanis, or other civic or business organizations and assists in the selection of the representatives of the community, county, state, and federal government is a responsible and important part of the community.)

   B. Represent organization

      (NOTE: The line technician is a representative of his/her organization to the community and should conduct himself/herself in a manner that is becoming to the employer on and off the job.)

   C. Contribute to community safety

      (NOTE: Hazards such as downed power lines and trees in power lines should be readily identified by line technician.)

II. Responsibilities of a line technician to the employer

   A. Reliability

      (NOTE: A good working relationship between the line technician and the employer cannot exist if the line technician is not reliable.)

   B. Loyalty

   C. Interest

      (NOTE: The line technician should show an interest in the job and the organization.)

   D. Assistance

      (NOTE: Assistance is often needed by both the employer and the consumer and should be given freely when needed.)

   E. Promptness

   F. Neatness

      (NOTE: Neatness and pride should be shown in personal appearance by the line technician.)

   G. Safety

INFORMATION SHEET

III. Information shown in organizational chart (Transparency 1)

   A. Relationship of each position to management

   B. Chain of command

   C. Reporting relationships

   D. Relationship of each department to other departments

   E. Relationship of management to directors

   F. Relationship of directors to consumer

IV. Departmental functions of line department

   A. Construct new line

   B. Retire line

   (NOTE: The term *line* includes pole, hardware, and all electrical equipment used in line construction.)

   C. Maintain existing line

   D. Assist other departments

   (NOTE: The line department assists the engineering, public relations, and office departments.)

V. Topics taught in this course

   A. Safety

      1. Personal

      2. Job

   B. Fundamentals of electricity

   C Equipment

      1. Hand tools

      2. Mobile

   D. Insulators and insulation

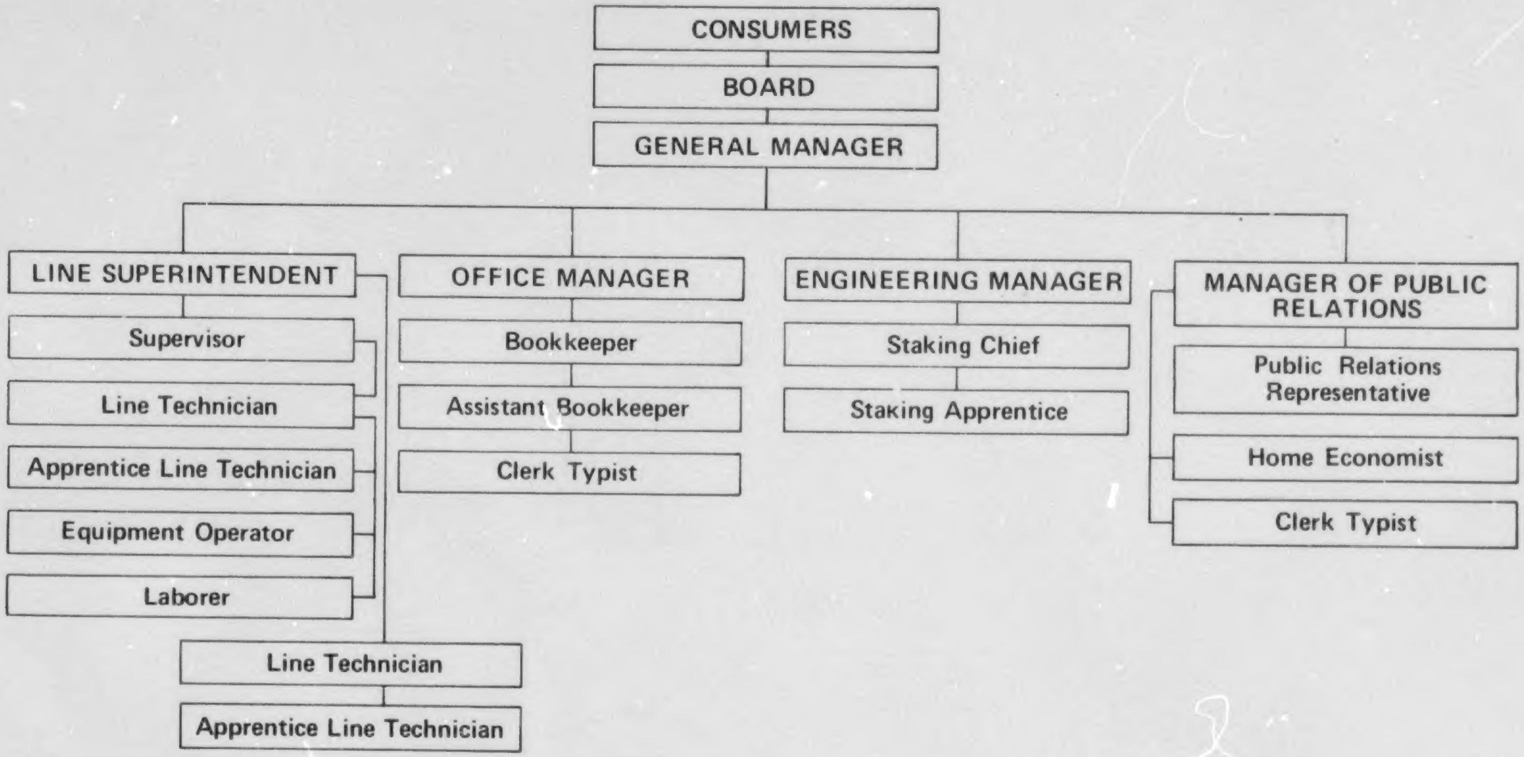
INFORMATION SHEET

- E. Line work
  - 1. Overhead construction
  - 2. Underground construction
  - 3. Maintenance
- F. Communications
  - 1. Personal
  - 2. Radio

VI. Benefits to students completing this line technician's training course

- A. Better qualifications
- B. More rapid advancement
- C. Greater employment opportunities

Organizational Chart



- CONSUMERS
  - BOARD
    - GENERAL MANAGER
      - LINE SUPERINTENDENT
        - Supervisor
          - Line Technician
          - Apprentice Line Technician
          - Equipment Operator
          - Laborer
        - Line Technician
          - Apprentice Line Technician
      - OFFICE MANAGER
        - Bookkeeper
          - Assistant Bookkeeper
            - Clerk Typist
      - ENGINEERING MANAGER
        - Staking Chief
          - Staking Apprentice
      - MANAGER OF PUBLIC RELATIONS
        - Public Relations Representative
        - Home Economist
        - Clerk Typist

(NOTE: This is a typical chart and does not necessarily represent all structures. Department titles will vary from one organization to another.)

INTRODUCTION TO POWER LINE TECHNICIAN'S TRAINING
UNIT II

TEST

NAME ______________________________ SCORE ____________________

1. List three responsibilities of a line technician to the community.

   a. ____

   b. ____

   c. ____

2. Select from the following list the responsibilities of a line technician to the employer by placing an "X" in the correct blanks.

   _____a. Reliability

   _____b. Loyalty

   _____c. Purchase of new equipment

   _____d. Promptness

   _____e. Assistance

   _____f. Interest

   _____g. Stockholder

   _____h. Neatness

   _____i. Safety

3. Select from the following statements the information that is shown in an organizational chart by placing an "X" in the blanks provided.

   _____a. Salary of all positions

   _____b. Relationship of each position to management

   _____c. Names of all personnel

   _____d. Reporting relationships

   _____e. Chain of command

   _____f. Relationship of each department to other departments _____g. Relationship of management to directors

_____h. Relationship of directors to consumer

4. List three departmental functions of a line department.

a. ____

b. ____

c. ____

5. Select from the following list the topics to be taught in this course by placing an "X" in the blanks provided.

_____a. Personal and job safety

_____b. Small appliance repair

_____c. Fundamentals of electricity

_____d. Personal and radio communications

_____e. Line maintenance

_____f. Television repair

_____g. Mobile equipment

_____h. Insulators and insulation

6. List two benefits to students completing the line technician's training course.

a. ____

b. ____

INTRODUCTION TO POWER LINE TECHNICIAN'S TRAINING
UNIT II

ANSWERS TO TEST

1. List three responsibilities of a line technician to the community.

   a. Participate in civic organizations, business clubs, churches, and political parties

   b. Represent organization

   c. Contribute to community safety

2. Select from the following list the importance of a line technician to the employer by placing an "X" in the correct blanks.

   _X_ a. Reliability

   _X_ b. Loyalty

   ____ c. Purchase of new equipment

   _X_ d. Promptness

   _X_ e. Assistance

   _X_ f. Interest

   ____ g. Stockholder

   _X_ h. Neatness

   _X_ i. Safety

3. Select from the following statements the information that is shown in an organizational chart by placing an "X" in the blanks provided.

   ____ a. Salary of all positions

   _X_ b. Relationship of each position to management

   ____ c. Names of all personnel

   _X_ d. Reporting relationships

   _X_ e. Chain of command

   _X_ f. Relationship of each department to other departments

   ____ g. Relationship of management to directors

   ____ h. Relationship of directors to consumer

4. List three departmental functions of a line department.

   (NOTE: Any three of the following are acceptable.)

   a. Construct new line

   b. Retire line

   c. Maintain existing line

   d. Assist other departments

5. Select from the following list the topics to be taught in this course by placing an "X" in the blanks provided.

   __X__ a. Personal and job safety

   _____ b. Small appliance repair

   __X__ c. Fundamentals of electricity

   __X__ d. Personal and radio communications

   __X__ e. Line maintenance

   _____ f. Television repair

   __X__ g. Mobile equipment

   __X__ h. Insulators and insulation

6. List two benefits to students completing the line technician's training course.

   (NOTE: Any two of the following are acceptable.)

   a. Better qualifications

   b. More rapid advancement

   c. Greater employment opportunities

JOB ADVANCEMENT
UNIT III

SUGGESTED ACTIVITIES

I. Suggested activities for instructor:

   A. Provide student with objective sheet.

   B. Provide student with information sheet.

   C. Discuss unit and specific objectives.

   D. Discuss information sheet.

   E. Give test.

II. Unit references:

   A. *You and Your Job: How to Keep It.* Chicago: J. G. Ferguson Publishing Co., 1968.

   B. *You and Your Job: Where Do You Go from Here?* J. G. Ferguson Publishing Co., 1968.

   C. Turcotte, Raymond J., and Braker, Clifton R. *Bricklaying Curriculum.* Stillwater: Oklahoma State Department of Vocational and Technical Education/Curriculum and Instructional Materials Center, 1977.

JOB ADVANCEMENT
UNIT III

INFORMATION SHEET

I. Terms and definitions

   A. Adaptability--Ability to adjust easily to new situations

   B. Cooperativeness--Ability to work with others toward a desired goal

   C. Goodwill--Feeling of rapport and respect that has been established between individuals

   D. Initiative--Act of being a self-starter; finding things that need to be done without being told

   E. Perseverance--Action of following a job through to completion

   F. Seniority--Status attained by length of continuous service

   G. Success--Attainment of desired goals

II. Characteristics employers consider when making promotions

   A. Attitude

   B. Seniority

   C. Knowledge of present job

   D. Quality of work

   E. Quantity of work

   F. Initiative

   G. Perseverance

   H. Cooperativeness

   I. Goodwill

   J. Adaptability

   K. Ability to think

   L. Training

   (NOTE: These characteristics are not listed in order of importance.)

INFORMATION SHEET

III. Attitudes

   A. Good

      1. Punctual

      2. Dependable

      3. Sincere

      4. Loyal

      5. Pride in job

      6. Cooperative

   B. Poor

      1. Loafing

      2. Gossiping

      3. Using company time for personal activities

      4. Sloppy work

      5. Taking chances

IV. Steps that will help in job advancement

   A. Work safely

   B. Master present job completely

   (NOTE: Follow directions, ask questions when unsure, follow standard practices, check quality of work, and keep standards high.)

   C. Develop a program of self-improvement

   (NOTE: This program should include improving your personality, increasing your skills, and continuing your education.)

   D. Show initiative on the job

   (NOTE: Take on additional responsibility and suggest improvements.)

V. Benefits of additional education and training

   A. Advancement and job stability

   B. Better pay

INFORMATION SHEET

- C. More challenging position
- D. Prestige
- E. Personal satisfaction
- F. Success

VI. Activities to better prepare for advancement

- A. Reading
    - 1. To improve general knowledge
    - 2. To improve communications
    - 3. To enlarge areas of interest
    - 4. To keep up-to-date in the field
- B. Joining professional organizations
- C. Being active in civic and community projects

VII. Reasons people do not succeed on the job

- A. Unable to get along with co-workers
- B. Unskilled
- C. Irresponsible
- D. Not dependable
- E. No initiative
- F. Unsafe worker

JOB ADVANCEMENT
UNIT III

TEST

NAME ______________________________ SCORE ____________________

1. Match the terms on the right to the correct definitions.

______a. Act of being a self-starter; finding things that need to be done without being told

______b. Ability to work with others toward a desired goal

______c. Feeling of rapport and respect that has been established between individuals

______d. Action of following a job through to completion

______e. Status attained by length of continuous service

______f. Ability to adjust easily to new situations

______g. Attainment of desired goals

1. Adaptability
2. Cooperativeness
3. Goodwill
4. Initiative
5. Perseverance
6. Success
7. Seniority

2. List five characteristics employers consider when making promotions.

a. ______________________________

b. ______________________________

c. ______________________________

d. ______________________________

e. ______________________________

3. Distinguish between good and poor work attitudes by placing a "G" in front of the statements below that indicate good attitudes and a "P" in front of the statements that indicate poor attitudes.

______a. Dependable

______b. Sincere

______c. Loafing

______d. Pride in job

______e. Punctual

______f. Gossiping

______g. Sloppy work

______h. Loyal

______i. Cooperative

______j. Using company time for personal activities

4. List four steps that will help in job advancement.

a. ____

b. ____

c. ____

d. ____

5. Select from the list below benefits of additional education and training by placing an "X" in the blanks.

______a. Better pay

______b. College degree

______c. Prestige

______d. Advancement and job stability

______e. Personal satisfaction

______f. More challenging position

______g. Success

6. Discuss three activities that will better prepare a person for advancement.

____

____

____

____

____

7. List four reasons people do not succeed on the job.

a. ______________________________

b. ______________________________

c. ______________________________

d. ______________________________

JOB ADVANCEMENT
UNIT III

ANSWERS TO TEST

1. Match the terms on the right to the correct definitions.

   _4_ a. Act of being a self-starter; finding things that need to be done without being told

   _2_ b. Ability to work with others toward a desired goal

   _3_ c. Feeling of rapport and respect that has been established between individuals

   _5_ d. Action of following a job through to completion

   _7_ e. Status attained by length of continuous service

   _1_ f. Ability to adjust easily to new situations

   _6_ g. Attainment of desired goals

   1. Adaptability
   2. Cooperativeness
   3. Goodwill
   4. Initiative
   5. Perseverance
   6. Success
   7. Seniority

2. List five characteristics employers consider when making promotions.

   (NOTE: Any five of the following are acceptable.)

   a. Attitude

   b. Seniority

   c. Knowledge of present job

   d. Quality of work

   e. Quantity of work

   f. Initiative

   g. Perseverance

   h. Cooperativeness

i. Goodwill

j. Adaptability

k. Ability to think

l. Training

3. Distinguish between good and poor work attitudes by placing a "G" in front of the statements below that indicate good attitudes and a "P" in front of the statements that indicate poor attitudes.

_G_ a. Dependable

_G_ b. Sincere

_P_ c. Loafing

_G_ d. Pride in job

_G_ e. Punctual

_P_ f. Gossiping

_P_ g. Sloppy work

_G_ h. Loyal

_G_ i. Cooperative

_P_ j. Using company time for personal activities

4. List four steps that will help in job advancement.

a. Work safely

b. Master present job completely

c. Develop a program of self-improvement

d. Show initiative on the job

5. Select from the list below benefits of additional education and training by placing an "X" in the blanks.

_X_ a. Better pay

____ b. College degree

_X_ c. Prestige

__X_ d. Advancement and job stability

__X_ e. Personal satisfaction

__X_ f. More challenging position

__X_ g. Success

6. Discuss three activities that will better prepare a person for advancement.
   a. Reading
      1) To improve general knowledge
      2) To improve communications
      3) To enlarge areas of interest
      4) To keep up-to-date in the field
   b. Joining professional organizations
   c. Being active in civic and community projects
7. List four reasons people do not succeed on the job

   (NOTE: Any four of the following are acceptable.)
   a. Unable to get along with co-workers
   b. Unskilled
   c. Irresponsible
   d. Not dependable
   e. No initiative
   f. Unsafe worker

GENERAL SAFETY
UNIT IV

UNIT OBJECTIVE

After completion of this unit, the student should be able to state the safety responsibilities of an REC employee, select from a list items which are subject to safety rules, and discuss OSHA requirements for first aid. This knowledge will be evidenced by scoring 100 percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. State the safety responsibilities of an REC employee.
2. List the steps of discipline for safety rule violations.
3. Select from a list items which are subject to safety rules.
4. State reasons for the importance of a safety policy.
5. Discuss OSHA requirements for first aid.
6. List the basic steps in first aid.
7. List steps of basic life support.

GENERAL SAFETY
UNIT IV

SUGGESTED ACTIVITIES

I. Suggested activities for instructor:

   A. Provide student with objective sheet.

   B. Provide student with information sheet.

   C. Discuss unit and specific objectives.

   D. Discuss information sheet.

   E. Provide opportunity for each student to be certified in administering cardiopulmonary resuscitation and first aid.

   F. Give test.

II. Unit references:

   A. Rural Electrification Administration. *Safety Manual for Electric Borrowers.* Washington, D.C.: U. S. Department of Agriculture, 1963.

   B. Department of Labor. "Safety and Health Regulations for Construction." *Federal Register*, vol. 37, no. 243, 16 December 1972.

GENERAL SAFETY
UNIT IV

INFORMATION SHEET

I. Safety responsibilities of REC employee

  A. Personal safety

  B. Safety of co-workers

  C. Safety of general public

  D. Familiarity with safety policy and rules

  E. Safe operation of equipment

II. Steps of discipline for safety rule violations

  A. First violation--Reprimand by supervisor

  B. Second violation--Reprimand by general manager in presence of supervisor

  C. Third violation--Suspension without pay

  D. Fourth violation--Dismissal

  (NOTE: The preceding steps are recommended by the REA, but discipline may be more severe in some cooperatives.)

III. Items subject to safety rules

  A. Vehicle operation

  B. Equipment operation

  C. Material handling

  D. Use and care of tools

  E. Use and care of protective equipment

  F. Construction

  G. Maintenance

  H. Office work

  I. Work procedures

  J. Communications

INFORMATION SHEET

IV. Importance of a safety policy

- A. Shows interest in safety for employees and public
- B. Establishes guidelines for safety program

V. OSHA requirements for first aid

- A. First-aiders must be certified by the American Red Cross or the Bureau of Mines
- B. Certified first-aider must be on each job site

VI. Basic steps for first aid

- A. Rescue victim
- B. Open airway
- C. Control bleeding

VII. Steps of basic life support

- A. Open airway
- B. Restore breathing
- C. Restore circulation

GENERAL SAFETY
UNIT IV

TEST

NAME ______________________________ SCORE ________________

1. State the safety responsibilities of an REC employee.

   a. ____

   b. ____

   c. ____

   d. ____

   e. ____

2. List the four steps of discipline for safety rule violations.

   a. First violation--________________________________

   b. Second violation--______________________________

   c. Third violation--________________________________

   d. Fourth violation--_______________________________

3. Select from the following list the items subject to safety rules by placing an "X" in the blanks provided.

   _____a. Equipment operation

   _____b. Maintenance

   _____c. Material handling

   _____d. Reporting

   _____e. Construction

   _____f. Use and care of tools

   _____g. Office work

   _____h. Typing

   _____i. Use and care of protective equipment

   _____j. Vehicle operation

   _____k. Work procedures

   _____l. Communications

4. State two reasons for the importance of a safety policy.

a. ______________________________

b. ______________________________

5. Discuss in a short paragraph the OSHA requirements for first aid.

____

____

____

____

6. List the three basic steps for first aid.

a. ______________________________

b. ______________________________

c. ______________________________

7. List the three steps of basic life support.

a. ______________________________

b. ______________________________

c. ______________________________

GENERAL SAFETY
UNIT IV

ANSWERS TO TEST

1. State the safety responsibilities of an REC employee.
   a. Personal safety
   b. Safety of co-workers
   c. Safety of general public
   d. Familiarity with safety policy and rules
   e. Safe operation of equipment
2. List the four steps of discipline for safety rule violations.
   a. First violation--Reprimand by supervisor
   b. Second violation--Reprimand by general manager in presence of supervisor
   c. Third violation--Suspension without pay
   d. Fourth violation--Dismissal
3. Select from the following list the items subject to safety rules by placing an "X" in the blanks provided.
   __X__ a. Equipment operation
   __X__ b. Maintenance
   __X__ c. Material handling
   _____ d. Reporting
   __X__ e. Construction
   __X__ f. Use and care of tools
   __X__ g. Office work
   _____ h. Typing
   __X__ i. Use and care of protective equipment
   __X__ j. Vehicle operation
   __X__ k. Work procedures
   __X__ l. Communications

4. State two reasons for the importance of a safety policy.
   a. Shows interest in safety for employees and public
   b. Establishes guidelines for safety program
5. Discuss in a short paragraph the OSHA requirements for first aid.
   a. First-aiders must be certified by the American Red Cross or the Bureau of Mines
   b. Certified first-aider must be on each job site
6. List the three basic steps for first aid.
   a. Rescue victim
   b. Open airway
   c. Control bleeding
7. List the three steps of basic life support.
   a. Open airway
   b. Restore breathing
   c. Restore circulation

PERSONAL AND JOB SAFETY
UNIT I

UNIT OBJECTIVE

After completion of this unit, the student should be able to describe the procedures for various types of rescue situations, select the proper fire extinguisher to control a fire, and drive safely. The student should be able to inspect and maintain mechanical equipment and work safely. This knowledge will be evidenced by scoring 100 percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms associated with personal and job safety to the correct definitions.
2. Describe the procedures to follow for various types of rescue situations.
3. List components necessary for fire.
4. Match classes of fires to the correct description of each.
5. Match types of fire extinguishers to the class or classes of fire each is best suited to extinguish.
6. List general safety precautions to observe during rescue.
7. Discuss in a short paragraph driving skills needed by a line technician.
8. List some poor attitudes that may cause accidents.
9. Select from a list requirements of a skilled driver.
10. List steps of defensive driving.
11. Identify shapes of traffic signs.
12. Select from a list some general safety precautions to observe when operating equipment.
13. State OSHA regulations for inspection of equipment.
14. Select from a list the items which should be inspected daily on mechanical equipment.
15. List methods for maintaining a clean and orderly work area.

16. Identify correct way to lift heavy objects.
17. Describe in a short paragraph the importance of safety communications.
18. Select from a list those items of importance that should be reported to the supervisor.
19. Select from a list items related to safety that a line technician should know concerning location and voltage.
20. State factors which determine the maximum weight which can be lifted by equipment.
21. Determine maximum weight that can be lifted by equipment at various angles.
22. Complete a safety pledge form.

PERSONAL AND JOB SAFETY
UNIT I

SUGGESTED ACTIVITIES

I. Suggested activities for instructor:

   A. Provide student with objective sheet.

   B. Provide student with information and assignment sheets.

   C. Make transparencies.

   D. Discuss unit and specific objectives.

   E. Discuss information and assignment sheets.

   F. Show film and other supplemental material on safety.

   G. Give test.

II. Unit references:

   A. *Oklahoma Driver's Manual.* rev. Oklahoma City: Oklahoma Department of Public Safety, 1976.

   B. Traffic Engineering and Safety Department. *New Road Signs Coming Your Way.* Washington, D.C.: American Automobile Association, 1971.

III. Film--"Fires and Wires." University of Michigan.

PERSONAL AND JOB SAFETY
UNIT I

INFORMATION SHEET

I. Terms and definitions

A. Accident--Unplanned or unscheduled event which may or may not cause personal injury or property damage

B. First aid--Immediate and temporary care of an accident or sudden illness victim until the service of a physician is obtained

C. Basic life support--Manual method of sustaining life until advanced life support system is available

Example: Cardiopulmonary resuscitation (CPR)

D. Personal protective equipment--Equipment worn on or about the body to help prevent bodily injury

E. Procedure--Series of steps followed in a definite order

F. Precaution--Measure taken beforehand to prevent harm or damage

G. Attitude--Mental position regarding an act or state

H. Rescue--Procedure of freeing from imminent danger by prompt action

I. Inspection--Act of viewing closely in critical appraisal

J. OSHA (Occupational Safety and Health Act)--Federal legislation designed to insure safe and sanitary working conditions for employees

K. Equipment safety--Proper use, care, and inspection of equipment

L. Job safety--Following procedures, codes, and methods prescribed in safety standards

M. Personal safety--Consistent use and care of items intended for use as safeguards

N. Safety--State or condition of being safe; freedom from danger, risk, or injury

II. Procedures for rescue situations

A. Pole top

1. Remove electrical source from victim

2. Restore breathing

INFORMATION SHEET

3. Lower victim to ground (Transparency 1)

(NOTE: If the victim is not breathing and does not have a pulse, lower victim to ground immediately and start CPR.)

B. Energized vehicle

1. Disconnect or remove source of electricity
2. Have fire extinguisher ready for use
3. Clear all lines from vehicle

(NOTE: Keep all persons clear of energized vehicle to prevent contact with it. If the person or persons in the energized vehicle are not injured they may jump clear, making sure that contact is not made between the vehicle and the ground.)

C. Electric shock

1. Remove source of electricity
2. Check pulse and respiration
3. Begin CPR if needed

D. Aerial device

1. Be sure vehicle is not energized
2. Lower platform or basket with override controls
3. Remove victim from platform or basket
4. Check victim for injuries, pulse, and respiration and begin CPR if needed

E. Fire

1. Place thick wet cloth over mouth and nose
2. Check doors for extreme heat before opening
3. Crouch low and stay behind door when opening

III. Components necessary for fire (Transparency 2)

A. Fuel

B. Heat

C. Oxygen

(NOTE: The removal of any one of the necessary components will prevent or extinguish a fire.)

INFORMATION SHEET

IV. Classes of fire

A. Class A--Fires that occur in ordinary combustible material such as wood, rags, and rubbish

B. Class B--Fires that occur with flammable liquids such as gasoline, oil, grease, paint, and thinners

C. Class C--Fires that occur in or near electrical equipment such as motors, transformers, switchboards, and electrical wiring

D. Class D--Fires that occur with combustible metals such as iron and magnesium

V. Types of extinguishers

A. Pressurized water--Used on Class A fires

B. Soda acid--Used on Class A fires

C. Carbon dioxide (CO_2)--Used on Class B and C fires

D. Dry chemical--Used on Class B, C, and D fires

(NOTE: Dry chemical extinguishers should be shaken before use to loosen packed chemicals.)

E. Foam--Used on Class A and B fires

(CAUTION: Do not use water on burning liquids because the fire will spread. Hot oil may explode if water comes in contact with it. Do not use water on electrical fires.)

VI. General safety precautions to observe during rescue

A. Do not endanger yourself just to be a hero

(NOTE: A rescue cannot be accomplished if the rescuer becomes another victim.)

B. Acquire the tools or equipment needed to carry out a rescue

C. Follow safety procedures

D. Notify proper authority

Examples: Supervisor, police, ambulance

E. Request assistance if needed

INFORMATION SHEET

VII. Driving skills needed by a line technician

- A. Obey all traffic laws
- B. Respect the rights of others
- C. Drive defensively
- D. Use seat belts
- E. Practice good housekeeping

  (NOTE: Items hanging from sun visors or laying on the dashboard restrict vision and should be properly stored.)

- F. Be aware of vehicle limitations

  Examples: Stopping distance, weight

- G. Drive only in areas where vehicle damage will not occur

VIII. Attitudes that may cause accidents

- A. Accidents happen to the other guy
- B. Shortcuts save time
- C. Safety rules are for other people
- D. Breaking safety rules is alright if you don't get caught
- E. I have done this before and didn't get hurt
- F. Speeding is alright if you are a good driver

IX. Requirements of a skilled driver

- A. Obeys all state and local traffic laws
- B. Maintains current license
- C. Allows no one to ride outside of vehicle
- D. Allows no one to mount or dismount while vehicle is in motion
- E. Passes other vehicles only when there is sufficient distance to do so safely
- F. Signals intent when turning, changing lanes, or stopping
- G. Yields to avoid an accident even if he/she has the right-of-way
- H. Follows other vehicles at a safe distance

INFORMATION SHEET

- I. Keeps transmission engaged when descending grades
- J. Checks to the rear before backing
- K. Maintains good visibility
- L. Sets parking brake, places transmission in gear, and chocks wheels when parking on a grade
- M. Attaches red flag to load if extended four feet or more beyond truck body
- N. Places flares or reflectors if vehicle is stalled

X. Steps of defensive driving

- A. Aim high in steering

  (NOTE: Seeing ahead of the car in front of you is the minimum distance that should be constantly observed.)

- B. Get the big picture

  (NOTE: Use your full vision capabilities in front, to the rear, and to each side.)

- C. Keep eyes moving

  (NOTE: Never let an object hold your attention. At highway speeds a lot can happen in two seconds.)

- D. Leave yourself an out

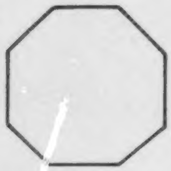
  (NOTE: Adjust your speed to the conditions and be ready to brake or veer if the situation requires it.)

- E. Make sure other drivers see you

  (NOTE: Traffic laws will not protect you if your presence is not known to approaching drivers.)

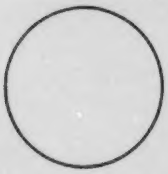
XI. Traffic signs (Transparency 3)

- A. Stop

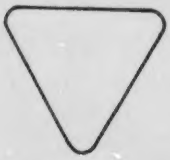


INFORMATION SHEET

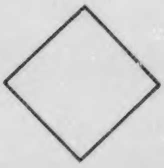
B. Railroad crossing



C. Yield right-of-way

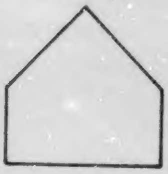


D. Warning

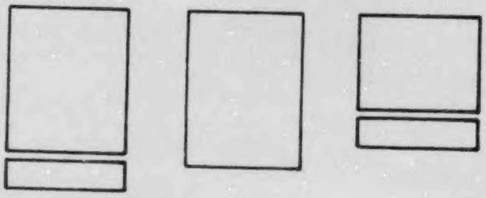


(NOTE: The diamond-shaped traffic sign indicates danger ahead, such as a sharp curve, narrow bridge, or stop sign.)

E. School area

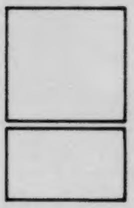


F. Service and guide



(NOTE: Service and guide signs inform of bike routes, hospitals, telephones, camping areas, and hiking trails.)

G. Regulatory



(NOTE: Regulatory signs indicate that certain things or actions are prohibited. These things or actions include no bicycles, no U-turns, or no trucks allowed, or no right or left turn.)

XII. Safety precautions to observe when operating equipment

A. Do not overload equipment

B. Do not let anyone stand under load or boom

C. Do not put side strain on rotating boom

D. Do not wear jewelry

E. Tie back long hair

F. Ground equipment when working near energized line

G. Make sure everyone is clear before extending outriggers or stabilizers

H. Be sure outriggers or stabilizers are on solid footing

I. Operate only the equipment you are trained and authorized to use

XIII. OSHA regulations for inspection of equipment

A. Inspection prior to each use by competent person designated by employer

B. Annual inspection by competent person, government agency, or private agency recognized by the Department of Labor

(NOTE: Inspection and testing of insulating equipment is done by an approved agency semi-annually.)

XIV. Procedure for inspection of mechanical equipment

A. Daily inspection of vehicles

1. Steering

2. Lights

INFORMATION SHEET

3. Horn
4. Wipers
5. Tires
6. Turn signals
7. Stop lights
8. Reflectors
9. Hand brake
10. Foot brake
11. Fire extinguisher
12. First aid kit

B. Daily inspection of rotating-lifting equipment

1. Hydraulic system filters
2. Hydraulic hoses
3. Hydraulic cylinders
4. Cylinder attachment points
5. Boom

(NOTE: A filter check will indicate excessive collection of contaminants if hydraulic cylinder seals or packing is damaged. A close check of hoses, cylinders, cylinder attachment points, and boom will reveal any broken welds or cracks.)

XV. Methods for maintaining a clean and orderly work area

A. Store equipment that is not in use

B. Stack packing materials and boxes and dispose of properly

C. Place materials in proper storage area after removing from job

D. Keep scrap and excess wire picked up and stored in proper place

E. Pick up all litter

F. Place all combustible or hazardous materials in proper containers

INFORMATION SHEET

XVI. Correct way to lift heavy objects (Transparency 4)

- A. Lift with legs, not with back
- B. Keep back straight
- C. Do not lift heavy objects without help

XVII. Importance of safety communications--Communications with other crews, co-workers, and supervisor aid in accident prevention

(NOTE: It is extremely important that other crews which might be working in the same area be aware of your location and job plans. An accident can easily happen if a line is energized by a crew that is unaware of your presence. If the person you are working with is working close to an energized conductor, remind him/her of the situation. He/she may not know how close the conductor is. This type of communication is essential for all members of a crew whether they are working on a structure or on the ground.)

XVIII. Important items that should be reported to the supervisor

- A. Unsafe conditions
- B. Unsafe tools
- C. Unsafe equipment
- D. Unsafe acts
- E. Job location
- F. Change of location
- G. Change of job plans
- H. All accidents

XIX. System knowledge related to safety

- A. Location
    1. Circuit breakers
    2. Regulators
    3. Capacitor stations
    4. Multi-feed transformer banks
    5. Private generators

INFORMATION SHEET

6. Phase transpositions
7. Underground feeders
8. Transformer banks
9. Other suppliers' lines
10. Lines paralleled with other suppliers' lines
11. Substations
12. Loop feeds

B. Voltage

1. Transformers (primary and secondary)
2. Distribution lines
3. Transmission lines
4. Metering equipment
5. Secondary lines
6. Service lines

(NOTE: Many systems use more than one distribution line voltage. This can be hazardous if the voltage rating of equipment to be installed is not the same as the line voltage to which the equipment is to be connected. Therefore, the line technician should be familiar with equipment locations and the line voltages.)

XX. Factors which determine maximum weights to be lifted by equipment

A. Design

(NOTE: Equipment constructed without stabilizers or outriggers will not have lifting capacities as great as equipment with them.)

B. Degree of elevation of lifting boom (Assignment Sheet #1)

(NOTE: The maximum lifting capacity of any boom type equipment is determined by the degree of elevation of the boom. The closer the boom is to 90° elevation, the greater the lifting capacity will be.)

INFORMATION SHEET

C. Size and condition of cable

(NOTE: Most equipment that is equipped with a winch has the capability of breaking a cable. The cable used should be of the proper size and type for the equipment and should be treated with care to avoid weakening its strength.)

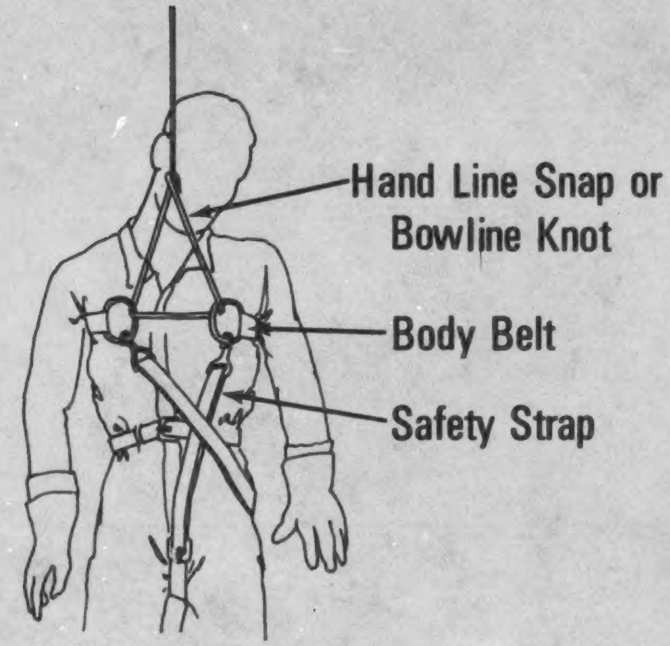
D. Rating (Transparency 5)

(NOTE: Each piece of equipment that is designed to lift material will have a specification plate which designates the maximum weight that can be lifted and the degree of elevation the boom must be to lift it. The lower the degree of elevation is, the lower the lifting capacity will be.)

E. Terrain

(NOTE: An unlevel terrain adds to the problem of equipment placement. Care should be taken to not lift poles or equipment from the downhill side of lifting equipment.)

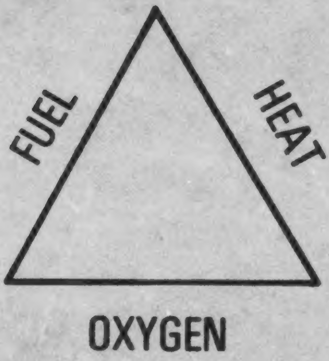
Lowering Victim To Ground



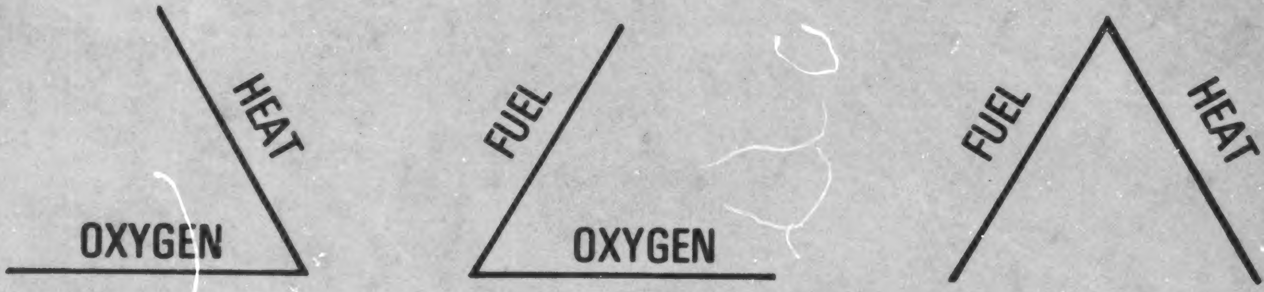
(NOTE: A hand line only may be used to quickly remove victim from pole.)

The Fire Triangle

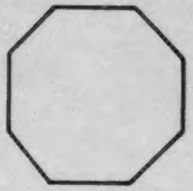
To produce fire, three things must be present at the same time.



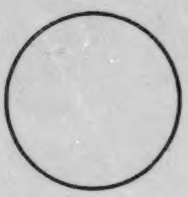
If any one of the three is missing, a fire cannot be started or, with the removal of any one, the fire will be extinguished.



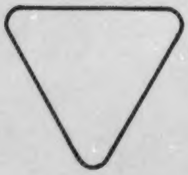
Traffic Signs



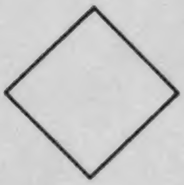
Stop



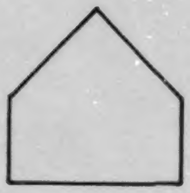
Railroad Crossing



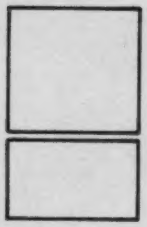
Yield Right-of-Way



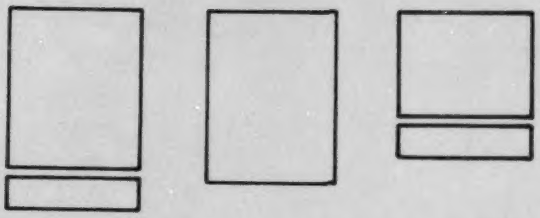
Warning



School Area



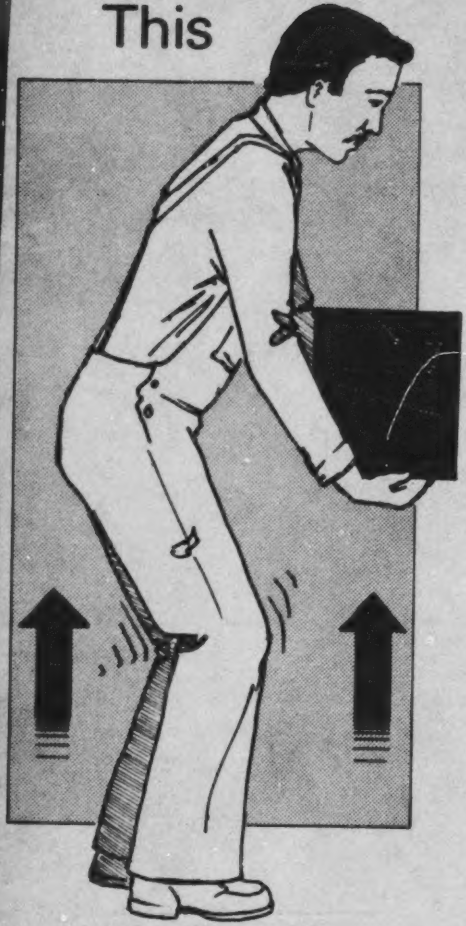
Regulatory



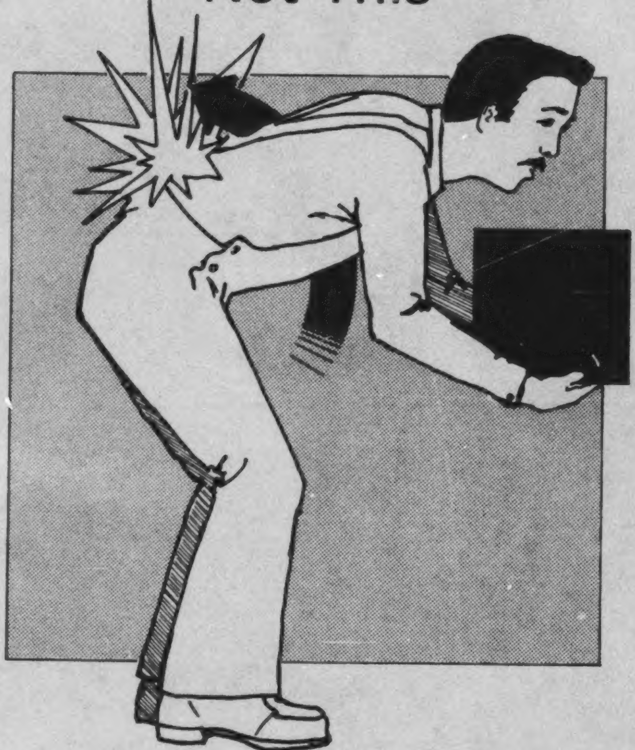
Service and Guide

Correct Way To Lift Heavy Objects

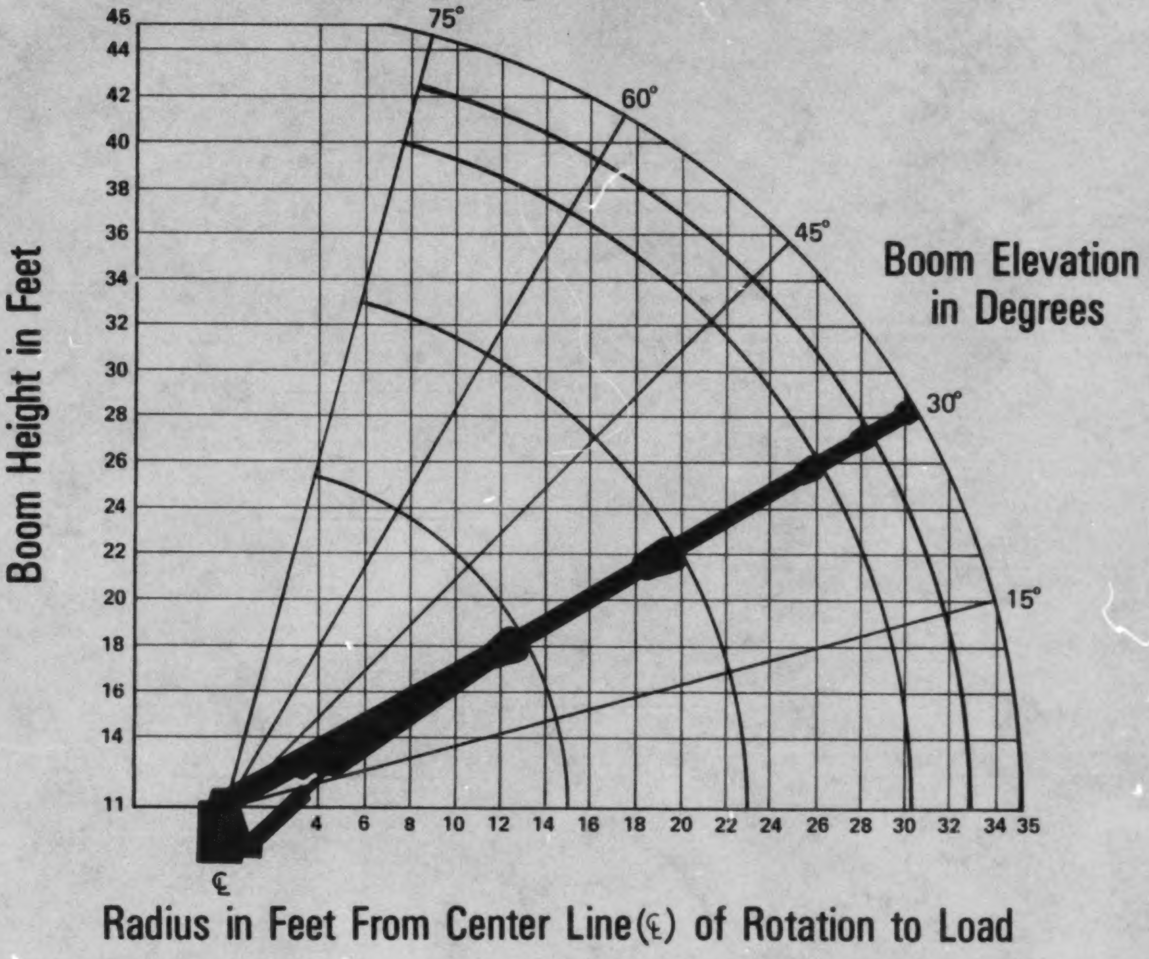
This



Not This



Capacity Chart



BOOM RETRACTED	LOAD RADIUS	4	5	6	8	10	12	15
	LOAD	11000	10000	8800	7400	6400	5600	4300

Deduct approx. 1000 pounds when equipped with digger.

BOOM EXTENDED	LOAD RADIUS	8	10	12	14	16	18	20	23
	LOAD	6200	5300	4600	4200	3800	3500	3200	2600

Deduct approx. 600 pounds when equipped with digger.

INSULATED BOOM EXTENSION	LOAD RADIUS	10	14	18	22	26	28	30	33	35
	LOAD	4500	3400	2900	2400	2200	2000	1800	1500	1200

Deduct approx. 500 pounds when equipped with digger.

DEDUCT 200 POUNDS FROM ALL CHARTS WHEN EQUIPPED WITH POLE CLAW.

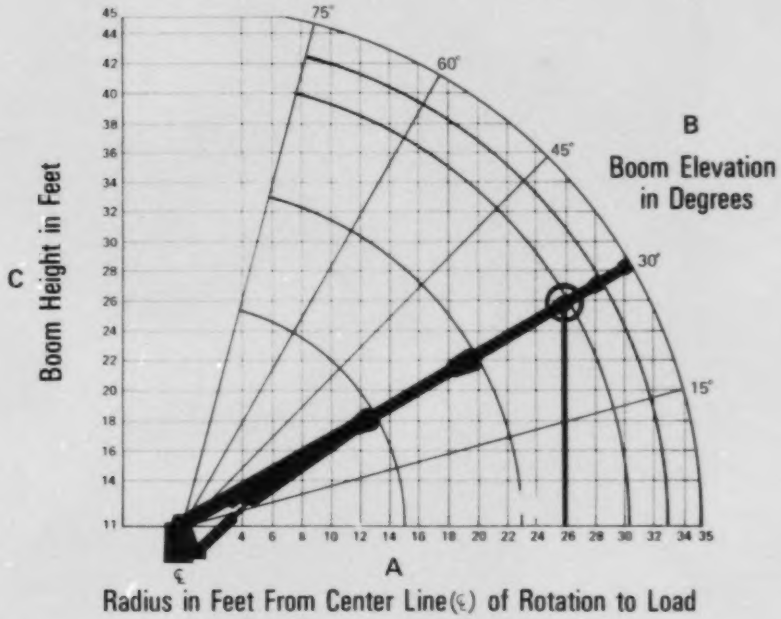
PERSONAL AND JOB SAFETY
UNIT I

ASSIGNMENT SHEET #1--DETERMINE MAXIMUM WEIGHT THAT CAN BE LIFTED BY EQUIPMENT AT VARIOUS ANGLES

The chart below indicates the maximum permissible load at various distances to load from center line (Line "A") and at various degrees of elevation (Line "B"). The numbers on the left side of the chart (Line "C") indicate the height in feet of the uppermost part of the boom at various feet of extension and at various degrees of elevation.

(NOTE: The degree of elevation is shown by a degree indicator attached to the side of the boom.)

Example: Radius to load is 26 feet (Line "A") and is elevated to 30 degrees (Line "B"). Maximum load is found in Line "F" under 26. Maximum load = 2200 lbs.



D

BOOM RETRACTED	LOAD RADIUS	4	5	6	8	10	12	15
	LOAD	11000	10000	8800	7400	6400	5600	4300

Deduct approx. 1000 pounds when equipped with digger.

E

BOOM EXTENDED	LOAD RADIUS	8	10	12	14	16	18	20	23
	LOAD	6200	5300	4600	4200	3800	3500	3200	2600

Deduct approx. 600 pounds when equipped with digger.

F

INSULATED BOOM EXTENSION	LOAD RADIUS	10	14	18	22	26	28	30	33	35
	LOAD	4500	3400	2900	2400	2200	2000	1800	1500	1200

Deduct approx. 500 pounds when equipped with digger.

DEDUCT 200 POUNDS FROM ALL CHARTS WHEN EQUIPPED WITH POLE CLAW.

ASSIGNMENT SHEET #1

1. Determine height of boom at 16 feet from center line to load and 15 degrees elevation.

2. Determine maximum weight that can be lifted with load at 16 feet from center line and boom elevated to 15 degrees when equipped with digger.

3. Determine maximum weight that can be lifted with load at 4 feet from center line and 75 degrees elevation when equipped with pole claw and boom retracted.

   (NOTE: In order for load to be 4 feet from center line, boom must be completely retracted.)

4. Determine maximum weight that can be lifted with load at 35 feet from center line and 0 degrees elevation when equipped with digger and pole claw.

PERSONAL AND JOB SAFETY
UNIT I

ASSIGNMENT SHEET #2--COMPLETE SAFETY PLEDGE FORM

______________________________, who is enrolled in the power line technician's training course, will as part of her/his experience, operate equipment, providing that the parent or guardian gives written permission.

It is understood that each student will be given proper instruction in the use of equipment and the safety procedures concerning it, before being allowed to operate it. The student must assume the responsibility for following safe practices and we therefore ask that the student subscribe to the following safety pledge.

1. I PROMISE TO FOLLOW ALL SAFETY RULES AND PRACTICES.
2. I PROMISE NEVER TO USE A PIECE OF EQUIPMENT WITHOUT FIRST HAVING PERMISSION FROM THE SUPERVISOR.
3. I WILL NOT ASK TO USE A PIECE OF EQUIPMENT UNLESS I HAVE BEEN INSTRUCTED IN ITS USE.
4. I WILL REPORT ANY ACCIDENT OR INJURY TO THE SUPERVISOR IMMEDIATELY.

DATE __________ STUDENT'S SIGNATURE __________________

I hereby give my consent to allow my son or daughter to operate all equipment necessary in carrying out the requirements of the course in which he/she is enrolled.

DATE __________ PARENT'S SIGNATURE __________________

(NOTE: Parental permission is necessary only if the student is a minor.)

PERSONAL AND JOB SAFETY
UNIT I

ANSWERS TO ASSIGNMENT SHEET #1

1. 15 feet
2. 3200 pounds
3. 10,800 pounds
4. 500 pounds

PERSONAL AND JOB SAFETY
UNIT I

TEST

NAME ______________________________ SCORE ________________

1. Match the terms on the right to the correct definitions.

_____a. Consistent use and care of items intended for use as safeguards

_____b. Federal legislation designed to insure safe and sanitary working conditions for employees

_____c. Mental position regarding an act or state

_____d. Procedure of freeing from imminent danger by prompt action

_____e. Act of viewing closely in critical appraisal

_____f. Proper use, care, and inspection of equipment

_____g. Series of steps followed in a definite order

_____h. Manual method of sustaining life until advanced life support system is available

_____i. Unplanned or unscheduled event which may or may not cause personal injury or property damage

_____j. Equipment worn on or about the body to help prevent bodily injury

_____k. Measure taken beforehand to prevent harm or damage

_____l. Immediate and temporary care of an accident or sudden illness victim until the service of a physician is obtained

_____m. Following procedures, codes, and methods prescribed in safety standards

_____n. State or condition of being safe; freedom from danger, risk, or injury

1. Accident
2. First aid
3. Basic life support
4. Personal protective equipment
5. Procedure
6. Precaution
7. Attitude
8. Rescue
9. Inspection
10. OSHA (Occupational Safety and Health Act)
11. Equipment safety
12. Job safety
13. Personal safety
14. Safety

2. Describe the procedure to follow for each of the rescue situations listed below.

   a. Pole top

   ____

   ____

   ____

   b. Energized vehicle

   ____

   ____

   ____

   c. Electric shock

   ____

   ____

   ____

   d. Aerial device

   ____

   ____

   ____

   e. Fire

   ____

   ____

   ____

3. List the three components necessary for fire.

   a. __________

   b. __________

   c. __________

4. Match the classes of fire on the right to the correct descriptions.

______a. Fires that occur in ordinary combustible material such as wood, rags, and rubbish

______b. Fires that occur in or near electrical equipment such as motors, transformers, switchboards, and electrical wiring

______c. Fires that occur with combustible metals such as iron and magnesium

______d. Fires that occur with flammable liquids such as gasoline, oil, grease, paint, and thinners

1. Class A
2. Class B
3. Class C
4. Class D

5. Match the types of fire extinguishers on the right to the class or classes of fire each is best suited to extinguish. Blanks may have more than one answer.

______a. Class A fire

______b. Class B fire

______c. Class C fire

______d. Class D fire

1. Dry chemical
2. Pressurized water
3. Foam
4. Carbon dioxide
5. Soda acid

6. List three general safety precautions to observe during rescue.

a. ____

b. ____

c. ____

7. Discuss in a short paragraph the driving skills needed by a line technician.

____

____

____

____

____

8. List three poor attitudes that may cause accidents.

a. ______________________________

b. ______________________________

c. ______________________________

9. Select from the following list those statements that are requirements of a skilled driver by placing an "X" in the blanks provided.

______a. Passes other vehicles only when there is sufficient distance to do so safely

______b. Exceeds speed limit only when passing other vehicles

______c. Allows no one to ride outside of vehicle

______d. Keeps transmission engaged when descending grades

______e. Maintains good visibility

______f. Sets parking brake, places transmission in gear, and chocks wheels when parking on a grade

______g. Places flares or reflectors if vehicle is stalled

______h. Attaches red flag to load if extended four feet or more beyond truck body

______i. Yields to avoid an accident even if he/she has the right-of-way

______j. Obeys most traffic laws

______k. Follows other vehicles at a safe distance

______l. Checks to the rear before backing

______m. Maintains current license

______n. Signals intent when turning, changing lanes, or stopping

______o. Allows no one to mount or dismount while vehicle is in motion

______p. Obeys all state and local traffic laws

10. List the five steps of defensive driving.

a. ______________________________

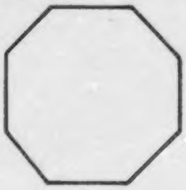
b. ______________________________

c. ______________________________

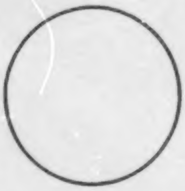
d. ______________________________

e. ______________________________

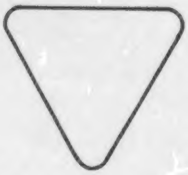
11. Identify the following shapes of traffic signs.



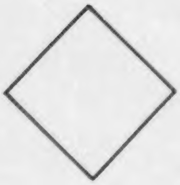
a. ____________



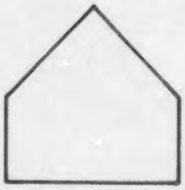
b. ____________



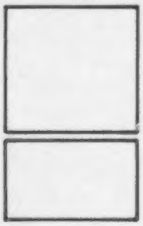
c. ____________



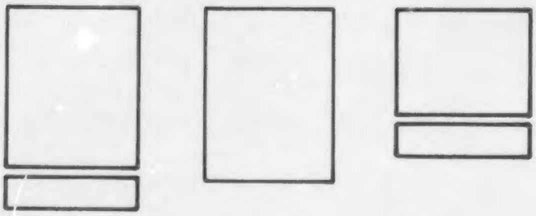
d. ____________



e. ____________



f. ____________



g. ____________

12. Select from the following list the general safety precautions to observe when operating equipment by placing an "X" in the blanks provided.

_____a. Tie back long hair

_____b. Ground equipment when working near energized line

_____c. Be sure outriggers or stabilizers are on solid footing

_____d. Overload only heavy equipment

_____e. Do not let anyone stand under load or boom

_____f. Do not wear jewelry

_____g. Make sure everyone is clear before extending outriggers or stabilizers

_____h. Do not put side strain on rotating boom

_____i. Do not overload equipment

_____j. Operate only the equipment you are trained and authorized to use

13. State OSHA regulations for inspection of equipment.

____

____

____

____

____

14. Select from the following list the items which should be inspected daily on mechanical equipment. Place an "X" in the blanks provided.

a. Vehicles

____ 1) Steering

____ 2) Transmission

____ 3) Foot brake

____ 4) Horn

____ 5) Wipers

____ 6) Tires

____ 7) Turn signals

____ 8) Stop lights

____ 9) Drive shaft

____10) Reflectors

____11) Hand brake

____12) Lights

____13) Fire extinguisher

____14) First aid kit

b. Rotating-lifting equipment

____ 1) Hydraulic system filters

____ 2) Coolant level

____ 3) Hydraulic hoses

____ 4) Hydraulic cylinders

____ 5) Cylinder attachment points

____ 6) Boom

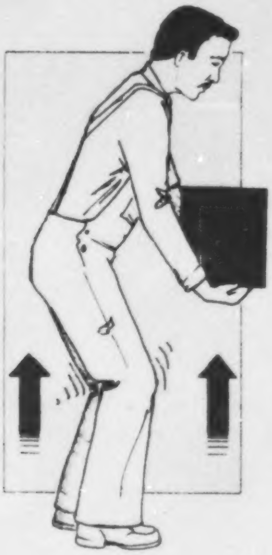
15. List three methods for maintaining a clean and orderly work area.

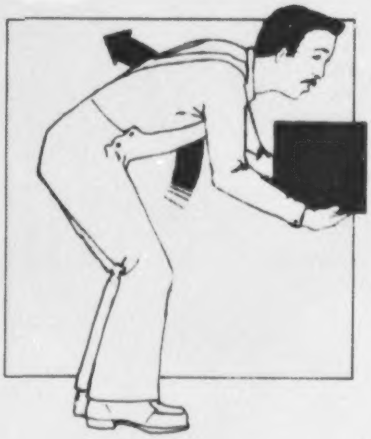
a. ____________________

b. ____________________

c. ____________________

16. Identify the correct way to lift heavy objects by circling the appropriate drawing.





17. Describe in a short paragraph the importance of safety communications.

____

____

____

18. Select from the following list the items that should be reported to the supervisor. Place an "X" in the blanks provided.

______a. Unsafe tools

______b. All accidents

______c. Unsafe conditions

______d. Unsafe acts

______e. Kinds of equipment

______f. Change of location

______g. Unsafe equipment

______h. Job location

19. Select from the list below items related to safety that a line technician should know concerning location and voltage. Place an "X" in the blanks provided.

a. Location

____ 1) Circuit breakers

____ 2) Regulators

____ 3) Capacitor stations

____ 4) Multi-feed transformer banks

____ 5) Private generators

____ 6) Phase transpositions

____ 7) Underground feeders

____ 8) Pole yard

____ 9) Transformer banks

____10) Other suppliers' lines

____11) Lines paralleled with other suppliers' lines

____12) Substations

____13) Loop feeds

b. Voltage

____ 1) Transformers (primary and secondary)

____ 2) Loading coils

____ 3) Distribution lines

____ 4) Metering equipment

____ 5) Service lines

____ 6) Transmission lines

____ 7) Secondary lines

20. State the five factors which determine the maximum weight which can be lifted by equipment.

a. ____________________

b. ____________________

c. ____________________

d. ____________________

e. ____________________

21. Determine maximum weight that can be lifted by equipment at various angles.

22. Complete a safety pledge form.

(NOTE: If these have not been accomplished prior to the test, ask the instructor when the above activities should be completed.)

PERSONAL AND JOB SAFETY
UNIT I

ANSWERS TO TEST

1. Match the terms on the right to the correct definitions.

13 a. Consistent use and care of items intended for use as safeguards

10 b. Federal legislation designed to insure safe and sanitary working conditions for employees

7 c. Mental position regarding an act or state

8 d. Procedure of freeing from imminent danger by prompt action

9 e. Act of viewing closely in critical appraisal

11 f. Proper use, care, and inspection of equipment

5 g. Series of steps followed in a definite order

3 h. Manual method of sustaining life until advanced life support system is available

1 i. Unplanned or unscheduled event which may or may not cause personal injury or property damage

4 j. Equipment worn on or about the body to help prevent bodily injury

6 k. Measure taken beforehand to prevent harm or damage

2 l. Immediate and temporary care of an accident or sudden illness victim until the service of a physician is obtained

12 m. Following procedures, codes, and methods prescribed in safety standards

14 n. State or condition of being safe; freedom from danger, risk, or injury

1. Accident
2. First aid
3. Basic life support
4. Personal protective equipment
5. Procedure
6. Precaution
7. Attitude
8. Rescue
9. Inspection
10. OSHA (Occupational Safety and Health Act)
11. Equipment safety
12. Job safety
13. Personal safety
14. Safety

2. Describe the procedure to follow for each of the rescue situations listed below.
    a. Pole top
        1) Remove electrical source from victim
        2) Restore breathing
        3) Lower victim to ground
    b. Energized vehicle
        1) Disconnect or remove source of electricity
        2) Have fire extinguisher ready for use
        3) Clear all lines from vehicle
    c. Electric shock
        1) Remove source of electricity
        2) Check pulse and respiration
        3) Begin CPR if needed
    d. Aerial device
        1) Be sure vehicle is not energized
        2) Lower platform or basket with override controls
        3) Remove victim from platform or basket
        4) Check victim for injuries, pulse, and respiration and begin CPR if needed
    e. Fire
        1) Place thick wet cloth over mouth and nose
        2) Check doors for extreme heat before opening
        3) Crouch low and stay behind door when opening
3. List the three components necessary for fire.
    a. Fuel
    b. Heat
    c. Oxygen

4. Match the classes of fire on the right to the correct descriptions.

__1__ a. Fires that occur in ordinary combustible material such as wood, rags, and rubbish

__3__ b. Fires that occur in or near electrical equipment such as motors, transformers, switchboards, and electrical wiring

__4__ c. Fires that occur with combustible metals such as iron and magnesium

__2__ d. Fires that occur with flammable liquids such as gasoline, oil, grease, paint, and thinners

1. Class A
2. Class B
3. Class C
4. Class D

5. Match the types of fire extinguishers on the right to the class or classes of fire each is best suited to extinguish. Blanks may have more than one answer.

__2,3,5__ a. Class A fire

__1,3,4__ b. Class B fire

__1,4__ c. Class C fire

__1__ d. Class D fire

1. Dry chemical
2. Pressurized water
3. Foam
4. Carbon dioxide
5. Soda acid

6. List three general safety precautions to observe during rescue.

(NOTE: Any three of the following are acceptable.)

a. Do not endanger yourself just to be a hero

b. Acquire the tools or equipment needed to carry out a rescue

c. Follow safety procedures

d. Notify proper authority

e. Request assistance if needed

7. Discuss in a short paragraph the driving skills needed by a line technician.

a. Obey all traffic laws

b. Respect the rights of others

c. Drive defensively

d. Use seat belts

e. Practice good housekeeping

f. Be aware of vehicle limitations

g. Drive only in areas where vehicle damage will not occur

8. List three poor attitudes that may cause accidents.

(NOTE: Any three of the following are acceptable.)

a. Accidents happen to the other guy

b. Shortcuts save time

c. Safety rules are for other people

d. Breaking safety rules is alright if you don't get caught

e. I have done this before and didn't get hurt

f. Speeding is alright if you are a good driver

9. Select from the following list those statements that are requirements of a skilled driver by placing an "X" in the blanks provided.

___X___ a. Passes other vehicles only when there is sufficient distance to do so safely

_______ b. Exceeds speed limit only when passing other vehicles

___X___ c. Allows no one to ride outside of vehicle

___X___ d. Keeps transmission engaged when descending grades

___X___ e. Maintains good visibility

___X___ f. Sets parking brake, places transmission in gear, and chocks wheels when parking on a grade

___X___ g. Places flares or reflectors if vehicle is stalled

___X___ h. Attaches red flag to load if extended four feet or more beyond truck body

___X___ i. Yields to avoid an accident even if he/she has the right-of-way

_______ j. Obeys most traffic laws

___X___ k. Follows other vehicles at a safe distance

___X___ l. Checks to the rear before backing

___X___ m. Maintains current license

_____n. Signals intent when turning, changing lanes, or stopping

_____o. Allows no one to mount or dismount while vehicle is in motion

_____p. Obeys all state and local traffic laws

10. List the five steps of defensive driving.

    a. Aim high in steering

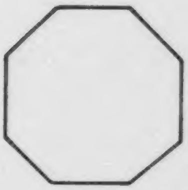
    b. Get the big picture

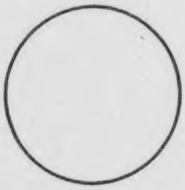
    c. Keep eyes moving

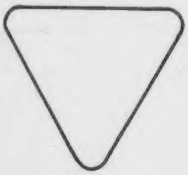
    d. Leave yourself an out

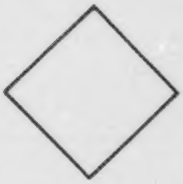
    e. Make sure other drivers see you

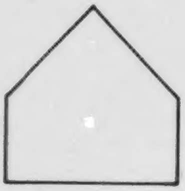
11. Identify the following shapes of traffic signs.

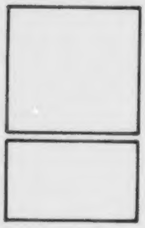

a. Stop

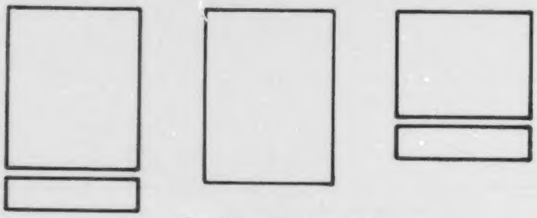

b. Railroad crossing


c. Yield right-of-way


d. Warning


e. School area


f. Regulatory


g. Service and guide

12. Select from the following list the general safety precautions to observe when operating equipment by placing an "X" in the blanks provided.

    __X__ a. Tie back long hair

    __X__ b. Ground equipment when working near energized line

    __X__ c. Be sure outriggers or stabilizers are on solid footing

    _____ d. Overload only heavy equipment

    __X__ e. Do not let anyone stand under load or boom

    __X__ f. Do not wear jewelry

    __X__ g. Make sure everyone is clear before extending outriggers or stabilizers

    __X__ h. Do not put side strain on rotating boom

    __X__ i. Do not overload equipment

    __X__ j. Operate only the equipment you are trained and authorized to use

13. State OSHA regulations for inspection of equipment.

    a. Inspection prior to each use by competent person designated by employer

    b. Annual inspection by competent person, government agency, or private agency recognized by the Department of Labor

14. Select from the following list the items which should be inspected daily on mechanical equipment. Place an "X" in the blanks provided.

    a. Vehicles

        __X__ 1) Steering

        _____ 2) Transmission

        __X__ 3) Foot brake

        __X__ 4) Horn

        __X__ 5) Wipers

        __X__ 6) Tires

        __X__ 7) Turn signals

        __X__ 8) Stop lights

        _____ 9) Drive shaft

_X_ 10) Reflectors

_X_ 11) Hand brake

_X_ 12) Lights

_X_ 13) Fire extinguisher

_X_ 14) First aid kit

b. Rotating-lifting equipment

_X_ 1) Hydraulic system filters

____ 2) Coolant level

_X_ 3) Hydraulic hoses

_X_ 4) Hydraulic cylinders

_X_ 5) Cylinder attachment points

_X_ 6) Boom

15. List three methods for maintaining a clean and orderly work area.

(NOTE: Any three of the following are acceptable.)

a. Store equipment that is not in use

b. Stack packing materials and boxes and dispose of properly

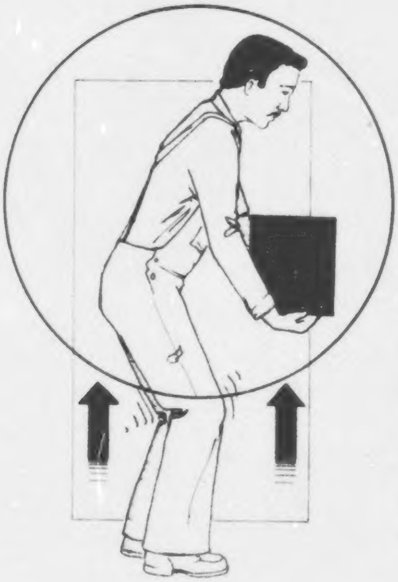
c. Place materials in proper storage area after removing from job

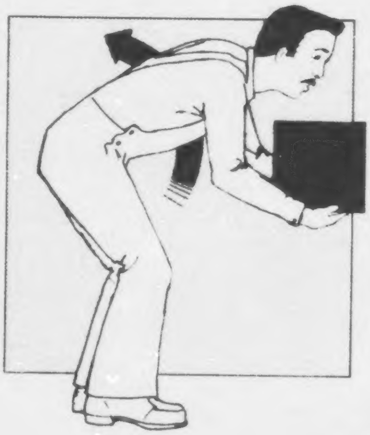
d. Keep scrap and excess wire picked up and stored in proper place

e. Pick up all litter

f. Place all combustible or hazardous materials in proper containers

16. Identify the correct way to lift heavy objects by circling the appropriate drawing.





17. Describe in a short paragraph the importance of safety communications.

Communications with other crews, co-workers, and supervisor aid in accident prevention

18. Select from the following list the items that should be reported to the supervisor. Place an "X" in the blanks provided.

X a. Unsafe tools

X b. All accidents

X c. Unsafe conditions

X d. Unsafe acts

____ e. Kinds of equipment

X f. Change of location

X g. Unsafe equipment

X h. Job location

19. Select from the list below items related to safety that a line technician should know concerning location and voltage. Place an "X" in the blanks provided.

a. Location

_X_ 1) Circuit breakers

_X_ 2) Regulators

_X_ 3) Capacitor stations

_X_ 4) Multi-feed transformer banks

_X_ 5) Private generators

_X_ 6) Phase transpositions

_X_ 7) Underground feeders

____ 8) Pole yard

_X_ 9) Transformer banks

_X_ 10) Other suppliers' lines

_X_ 11) Lines paralleled with other suppliers' lines

_X_ 12) Substations

_X_ 13) Loop feeds

b. Voltage

_X_ 1) Transformers (primary and secondary)

____ 2) Loading coils

_X_ 3) Distribution lines

_X_ 4) Metering equipment

_X_ 5) Service lines

_X_ 6) Transmission lines

_X_ 7) Secondary lines

20. State the five factors which determine the maximum weight which can be lifted by equipment.
    a. Design
    b. Degree of elevation of lifting boom
    c. Size and condition of cable
    d. Rating
    e. Terrain
21. Determine maximum weight that can be lifted by equipment at various angles.
22. Complete a safety pledge form.

(NOTE: Activities 21 and 22 should be evaluated to the satisfaction of the instructor.)

COMMUNICATIONS
UNIT II

UNIT OBJECTIVE

After completion of this unit, the student should be able to communicate correctly with others by radio and by using hand signals. This knowledge will be evidenced by scoring 85 percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. List types of communications necessary for an REC employee.
2. Select from a list those items of communication that are important between fellow workers.
3. List items of communication that are important between the worker and the supervisor.
4. Select from a list those items of communication that are important between the worker and the general public.
5. Identify hoist signals.
6. Identify winch line signals.
7. Identify hand signals used in boom operations.
8. Identify hand signals used when maneuvering vehicles.
9. Identify line work signals.
10. Select from a list the proper radio procedures.
11. State emergency radio procedure.
12. Select from a list the prohibited uses of the radio.
13. Match radio code signal numbers to the correct meanings.

COMMUNICATIONS
UNIT II

SUGGESTED ACTIVITIES

I. Suggested activities for instructor:

   A. Provide student with objective sheet.

   B. Provide student with information sheet.

   C. Discuss unit and specific objectives.

   D. Discuss information sheet.

   E. Have student practice hand signals.

   F. Have student role play using the radio.

   G. Give test.

II. Unit references:

   A. *Federal Communications Commission Rules and Regulations.* vol. 1. Washington, D.C.: Federal Communications Commission, April 1975.

   (NOTE: This publication is available from the Federal Communications Commission, 1919 M Street NW, Washington, D.C. 20554.)

   B. Department of Labor. "Safety and Health Regulations for Construction." *Federal Register,* vol. 37, no. 243, 16 December 1972.

COMMUNICATIONS
UNIT II

INFORMATION SHEET

I. Types of necessary communications

   A. Verbal

      (NOTE: Communications with the supervisor, crew members, and general public are among the most important communications.)

   B. Hand signals

      (NOTE: When working with equipment, noise levels make it difficult to communicate verbally. The knowledge and use of hand signals is an important part of communication under these conditions.)

   C. Radio

      (NOTE: Communicating by radio is the most efficient means of contacting crews in the field or obtaining information from the base station. Knowledge of the use and procedure of radio operation is an essential part of communications. If an emergency situation exists, radio use should be held to a minimum in order to let those involved transmit their messages.)

   D. Written

      (NOTE: Any information needed for records or referral should be in written form.)

II. Communications between fellow workers

   A. Pole buddy or other crew members

      1. What you are doing

      2. What your buddy's position is in relation to energized conductors or other unsafe conditions

   B. Other crews

      1. Where you are

      2. What you are doing

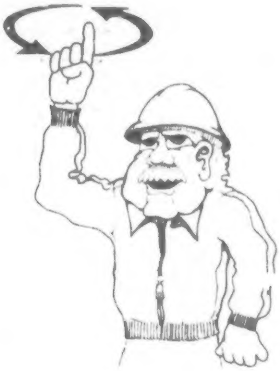
INFORMATION SHEET

- C. Radio dispatcher
    - 1. When you arrive at a job site
    - 2. When you leave a job site
    - 3. When you are going to be away from your radio

  (NOTE: All activities should be coordinated through the dispatcher.)

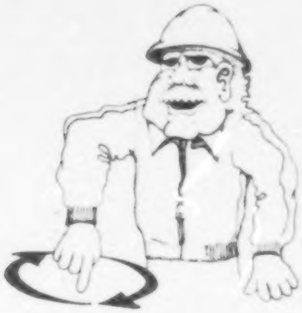
- III. Personal communications with the supervisor
    - A. Worker's responsibility
    - B. Supervisor's responsibility
    - C. Worker's authority
    - D. Supervisor's authority
    - E. Unsafe conditions of tools and equipment
    - F. Unsafe acts
    - G. All accidents
- IV. Communications with the general public
    - A. Programs of your organization
    - B. Purpose of your organization
    - C. Hazards to the public at job site

      (NOTE: Warning signs or barricades should be placed to protect the public.)
- V. Hoist signals (Transparency 1)
    - A. Raise the load

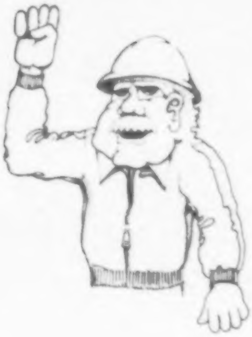


INFORMATION SHEET

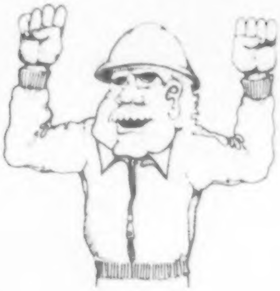
B. Lower the load



C. Stop



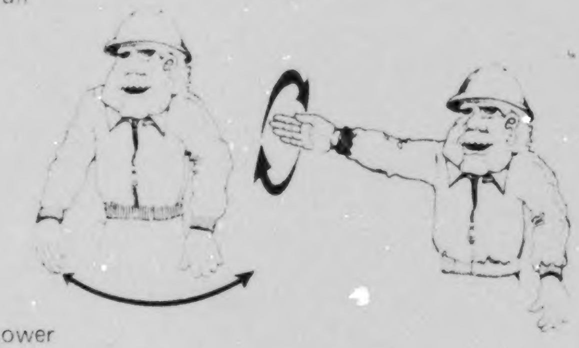
D. Emergency stop



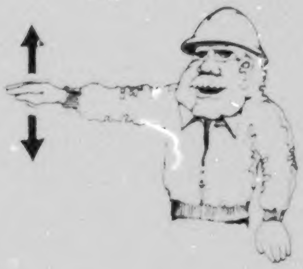
INFORMATION SHEET

VI. Winch line signals (Transparency 2)

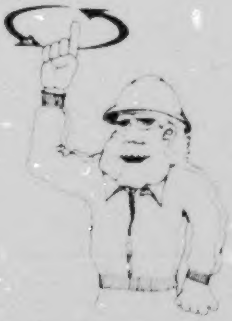
A. Pull



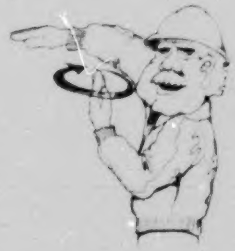
B. Lower



C. Hoist

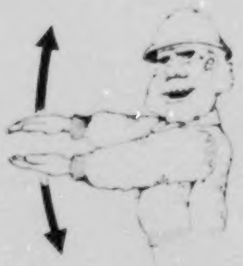


D. Take up slow or raise a little



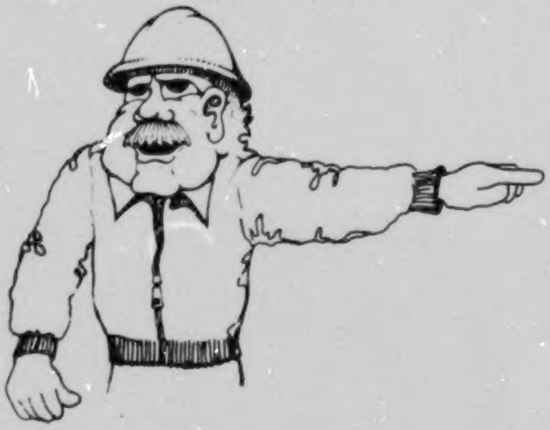
INFORMATION SHEET

E. Slack off slow or lower a little

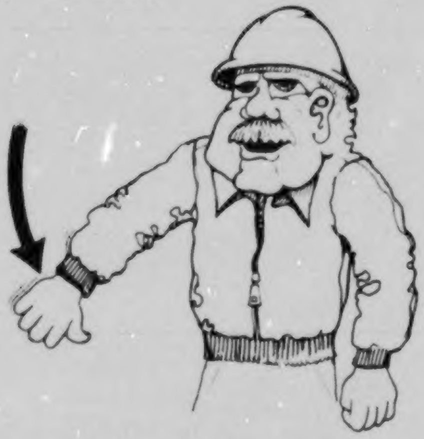


VII. Hand signals for boom operations (Transparency 3)

A. Swing in direction finger points

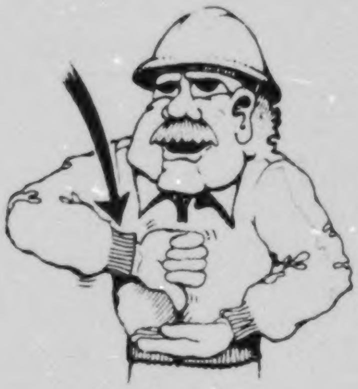


B. Lower the boom

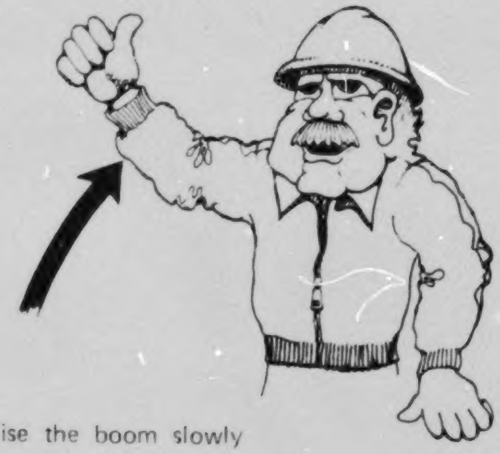


INFORMATION SHEET

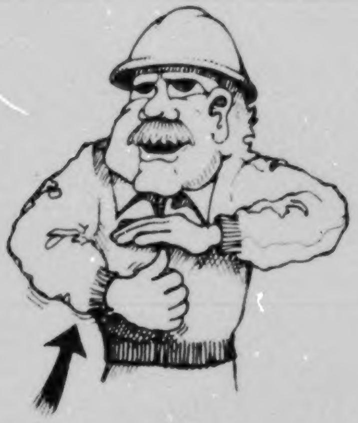
C. Lower the boom slowly



D. Raise the boom

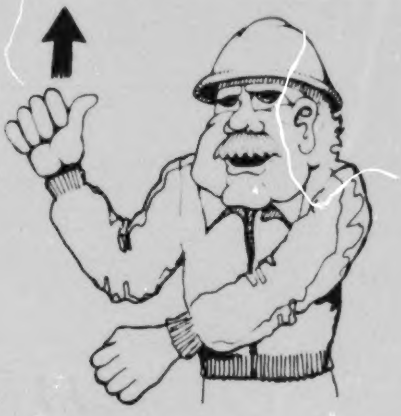


E. Raise the boom slowly

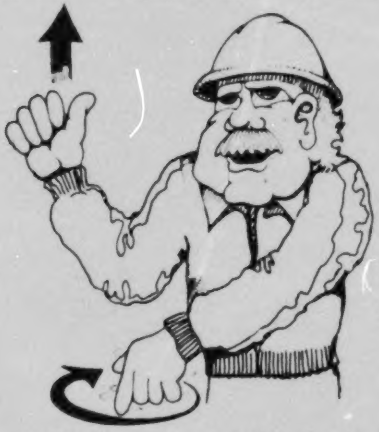


INFORMATION SHEET

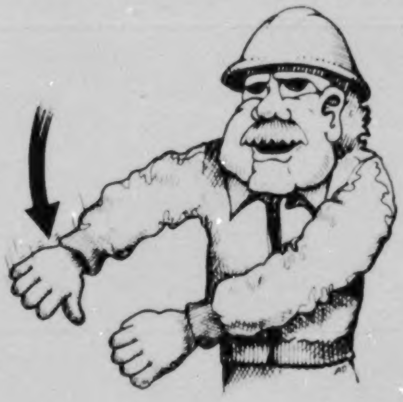
F. Raise the boom and hold the load



G. Raise the boom and lower the load

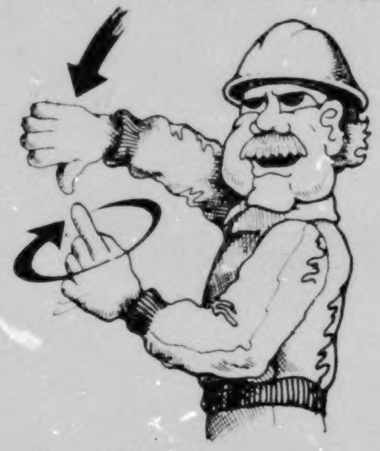


H. Lower the boom and hold the load

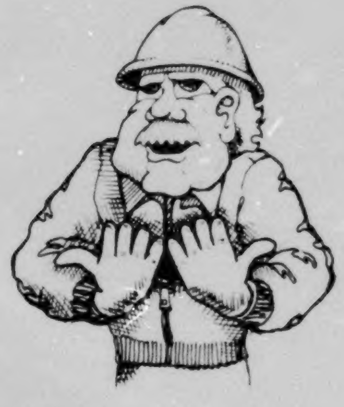


INFORMATION SHEET

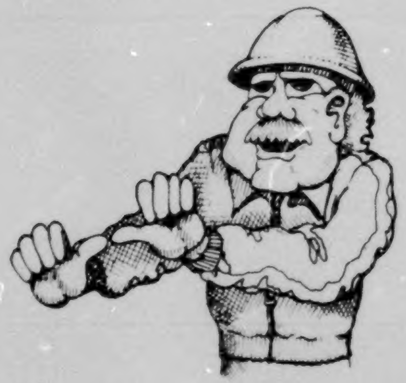
I. Lower the boom and raise the load



J. Crowd or extend



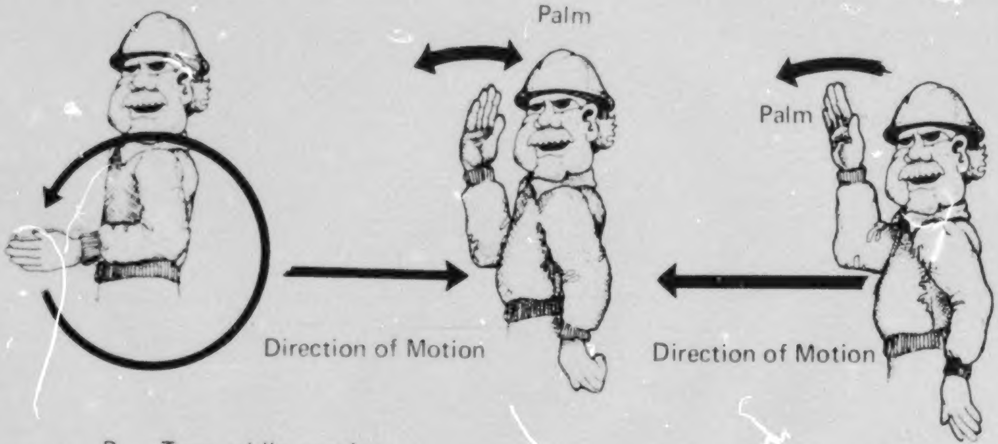
K. Rehaul or retract



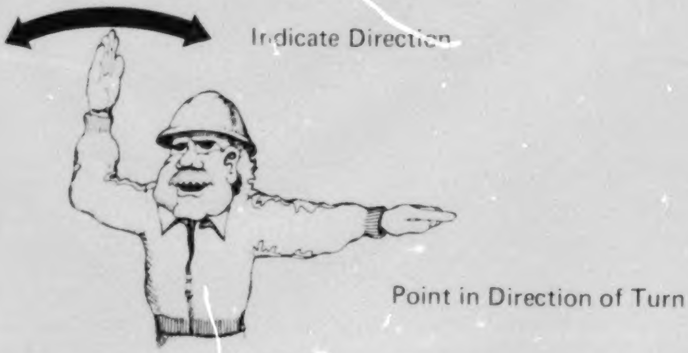
INFORMATION SHEET

VIII. Hand signals for maneuvering vehicle (Transparency 4)

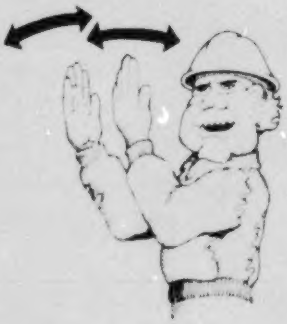
A. Move



B. Turn while moving


Indicate Direction
Point in Direction of Turn

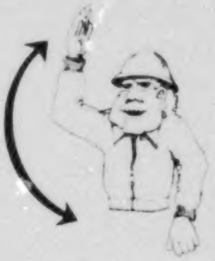
C. Straighten out



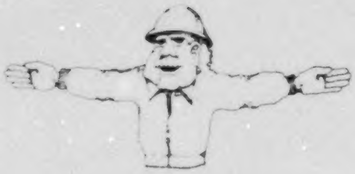
INFORMATION SHEET

IX. Standard signals for linework (Transparency 5)

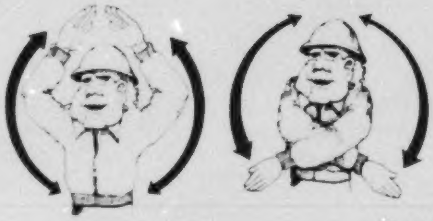
A. Pull up wire



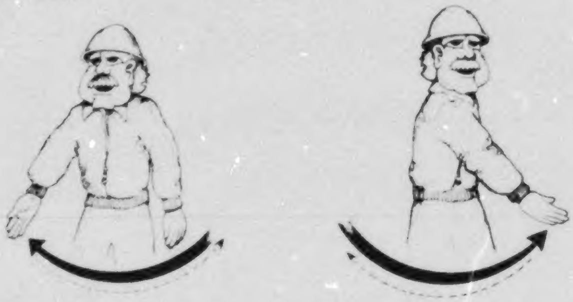
B. Stop



C. All off



D. Slack back



INFORMATION SHEET

X. Proper radio procedures

A. Hold microphone three to four inches from mouth

(NOTE: Many radio systems use a relay unit to transmit and receive messages. Because there is a time delay of one or two seconds required for the relay to operate, wait one or two seconds after keying microphone before giving message.)

B. Speak clearly in normal voice tone and volume

C. Give your call letters and unit number and the unit number you are calling

Example: KG-7751 unit 3 to unit 7

D. Keep message as brief and precise as possible

E. Clear the air when message is complete by giving unit call letters and unit number

Examples: KG-7751 unit 3 clear with unit 7
KG-7751 unit 7 clear with unit 3

F. Receive calls from other units or the base station by giving your call letters and unit number

Example: KG-7751 unit 3 to base, over

G. Call the base station by giving your unit number and the call letters of the base station

Example: Unit 3 to KKJ-317

(NOTE: Always notify the radio dispatcher when you are going to be away from your radio.)

XI. Emergency procedure

A. Have necessary information ready

1. Location

2. Type of accident or emergency

3. Type of assistance needed

Example: Ambulance, fire truck, police

INFORMATION SHEET

B. Call dispatcher and give information

C. Wait for verification

(NOTE: Be sure the information you have given is clearly understood by the dispatcher.)

XII. Prohibited uses of the two-way radio

A. Obscene, profane, or indecent language

B. Music or sound effects

C. Unnecessary or personal conversations

D. Messages not directed to any one person

E. Interference with other communications

F. Using messages with special meanings

G. Selling something

H. Calls to or conversations with stations other than your own

I. Relaying messages for someone other than your system units except in an emergency

XIII. Radio code signals

A. 10-0--Caution

B. 10-1--Unable to copy; change location

C. 10-2--Signal good

D. 10-4--Acknowledgement

E. 10-5--Relay

F. 10-6--Busy; stand by unless urgent

G. 10-7--Out of service (give location and/or telephone number)

H. 10-8--In service

I. 10-9--Repeat

J. 10-12--Stand by (stop)

INFORMATION SHEET

K. 10-20--Location

L. 10-21--Call . . . by telephone

M. 10-22--Disregard

N. 10-23--Arrived at scene

O. 10-24--Assignment completed

P. 10-25--Report in person to (meet) . . .

Q. 10-30--Illegal use of radio

R. 10-33--Emergency situation

S. 10-41--Beginning tour of duty

T. 10-42--Ending tour of duty

U. 10-51--Wrecker needed

V. 10-52--Ambulance needed

W. 10-66--Message cancellation

X. 10-68--Dispatch information

Y. 10-69--Message received

Z. 10-74--Negative

AA. 10-75--In contact with

BB. 10-76--En route

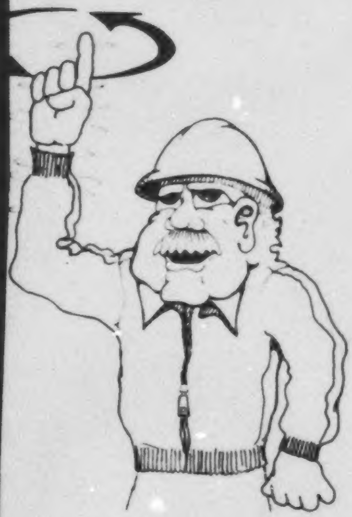
CC. 10-77--ETA (estimated time of arrival)

DD. 10-78--Need assistance

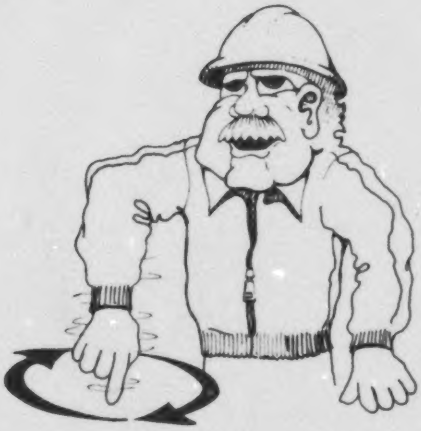
EE. 10-84--If meeting . . . advise ETA

FF. 10-97--Check (test) signal

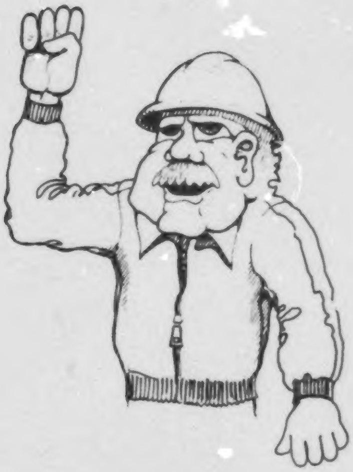
Hoist Signals



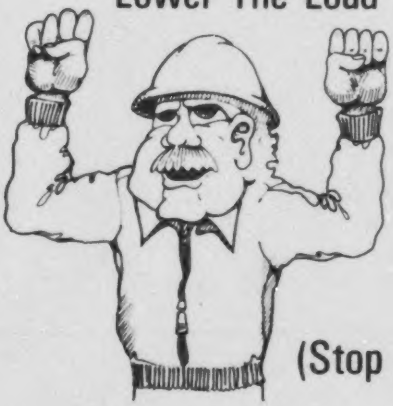
Raise The Load



Lower The Load



Stop

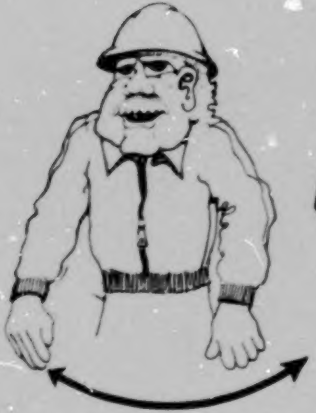


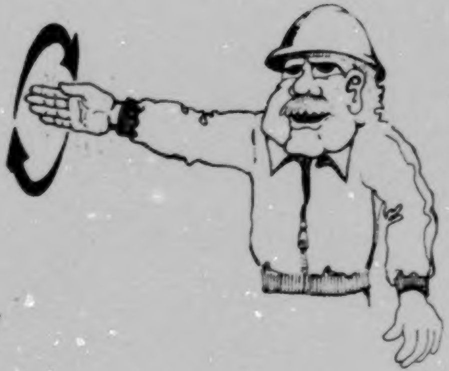
Emergency Stop

(Stop All Motion As Quickly As Possible)

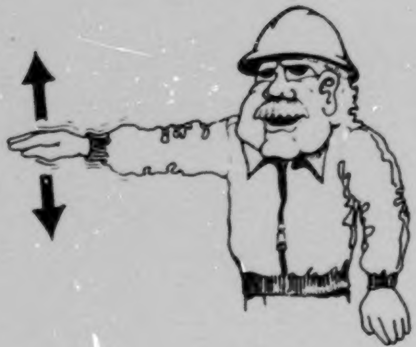
Winch Line

Pull

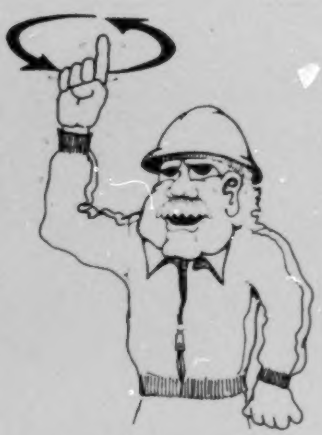




Lower

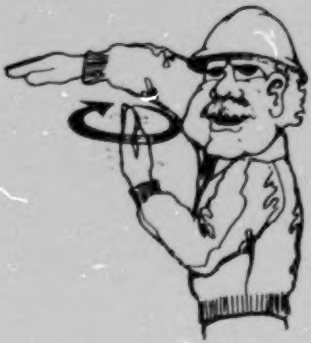


Hoist



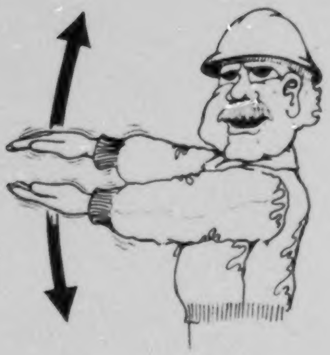
Take Up Slow Or Raise A Little

Indicate amount of raise by spread of hands

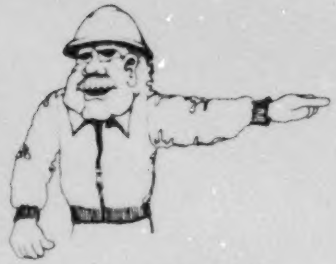


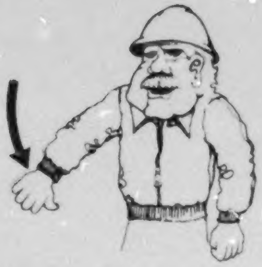
Slack Off Slow Or Lower A Little

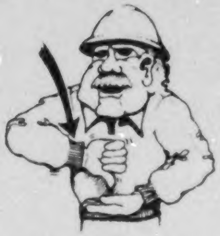
Indicate amount of lower by spread of hands

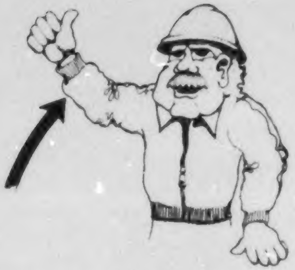


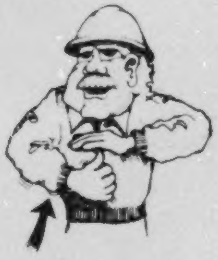
Hand Signals For Boom Operation

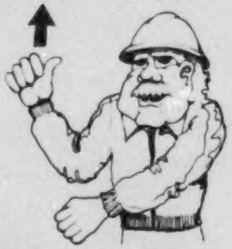

Swing In Direction
Finger Points

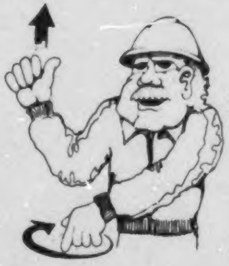

Lower The Boom

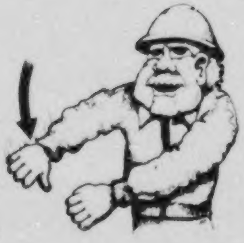

Lower The Boom Slowly

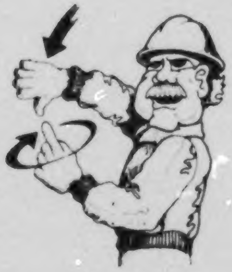

Raise The Boom

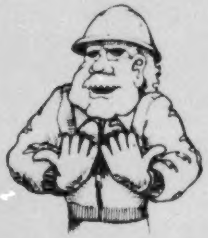

Raise The Boom Slowly

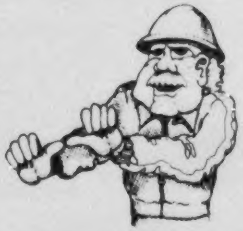

Raise The Boom And
Hold The Load


Raise The Boom And
Lower The Load


Lower The Boom
And Hold The Load


Lower The Boom
And Raise The Load

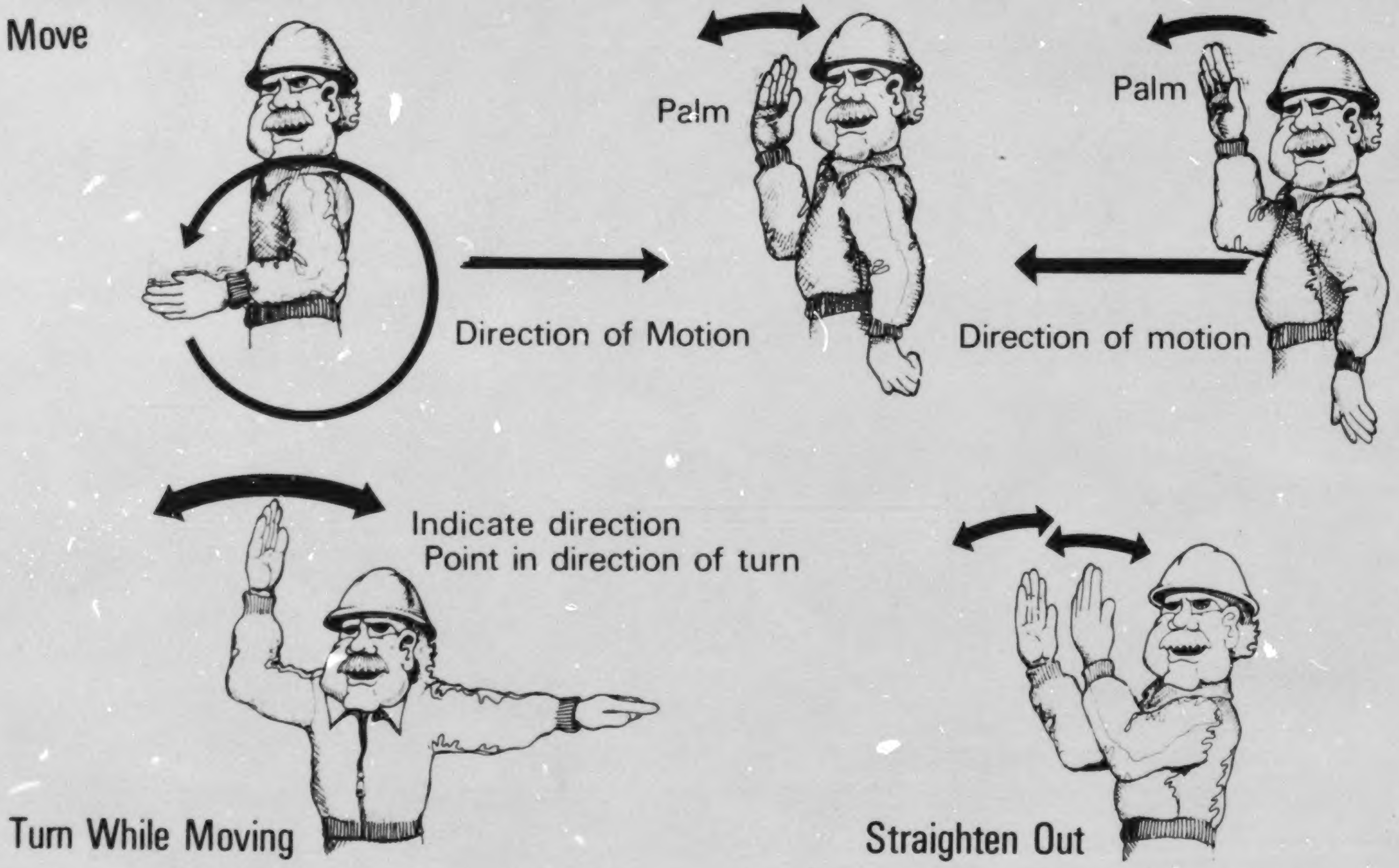

Crowd Or Extend


Rehaul Or Retract

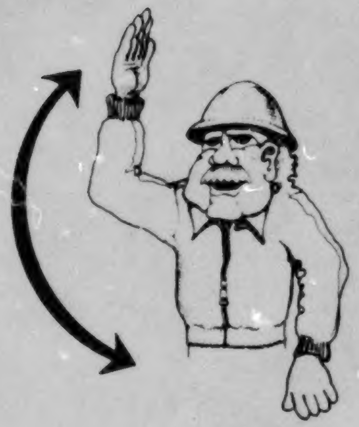
TM 3

PLT - 75-B

Maneuvering Vehicle

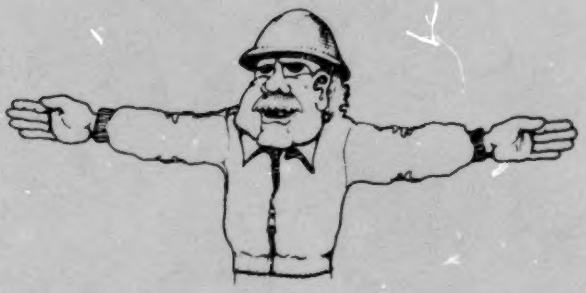


Standard Signals For Linework



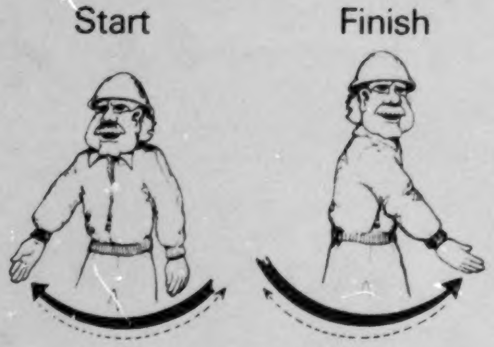
Pull Up Wire

Indicated by arm up, bent at elbow, and swinging down to side



Stop

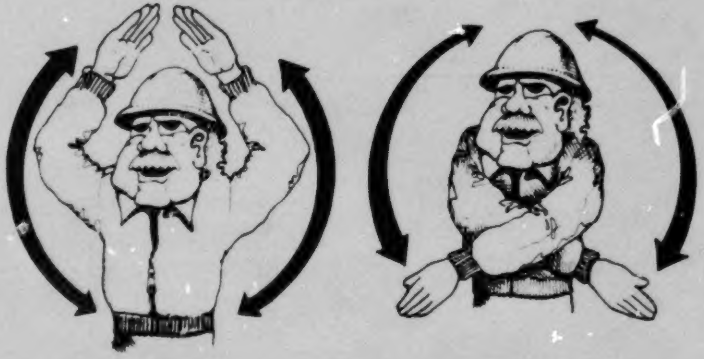
Indicated by both arms out horizontal



Slack Back Signal

Indicated by arm down, body stooping over sideways, arm swinging from side to side

All Off Signal



Indicated by arms crossed and over head

and

Swinging down to a crossed position below waist

COMMUNICATIONS
UNIT II

TEST

NAME ________________________ SCORE ______________

1. List four types of necessary communications for an REC employee.

   a. ____________________

   b. ____________________

   c. ____________________

   d. ____________________

2. Select from the following list the items of communication that are important between fellow workers.

   a. Pole buddy or other crew members

      ____1) What you are doing

      ____2) When lunch time is

      ____3) What your buddy's position is in relation to energized conductors or unsafe conditions

   b. Other crews

      ____1) Where you are

      ____2) What you are doing

      ____3) What time it is

   c. Radio dispatcher

      ____1) When you are going to be away from your radio

      ____2) When you arrive at a job site

      ____3) When you leave a job site

      ____4) When you leave on vacation

3. List four items of communication that are important between the worker and the supervisor.

a. ______________________________

b. ______________________________

c. ______________________________

d. ______________________________

4. Select from the following list those items of communication that are important between the worker and the general public.

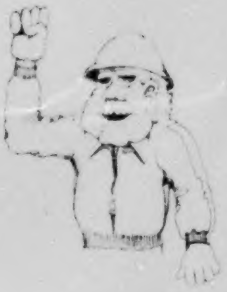
______a. Programs of your organization

______b. Hazards to the public at job site

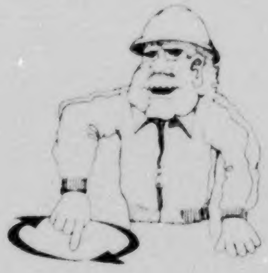
______c. Purpose of your organization

______d. Responsibilities of your job

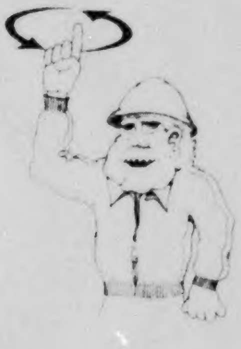
5. Identify the following hoist signals.



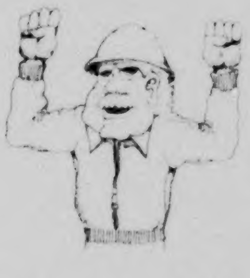
a. ____________________



b. ____________________

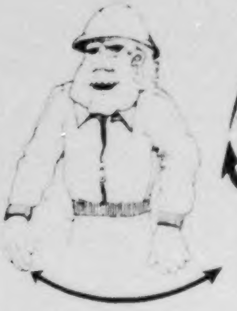


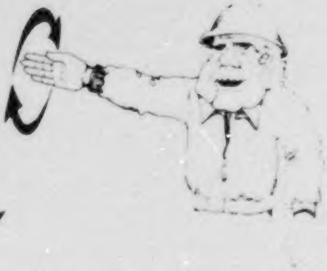
c. ____________________

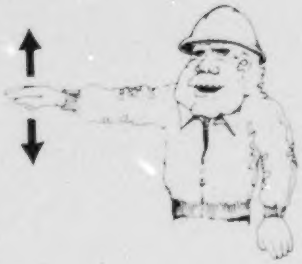


d. ____________________

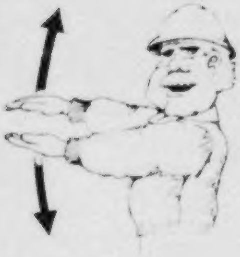
6. Identify the following winch line signals.

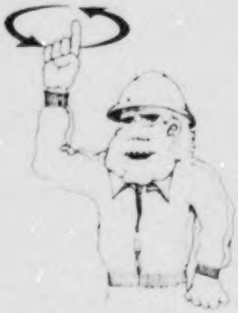


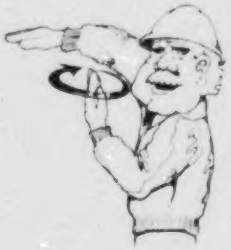




a. ____________________ b. ____________________

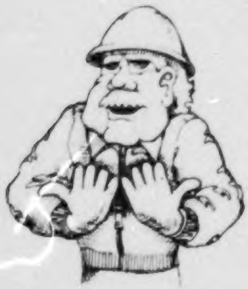


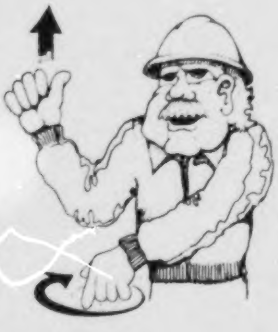


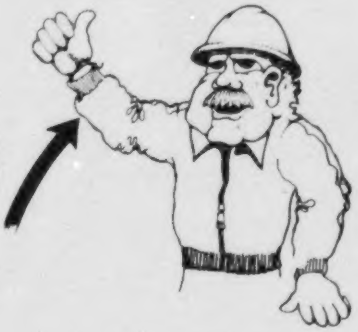


c. __________________ d. __________________ e. __________________

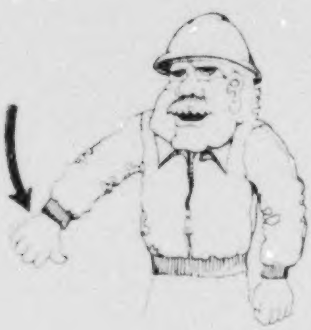
7. Identify the following hand signals used in boom operations.



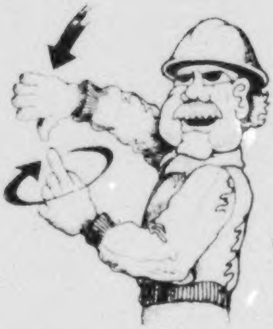




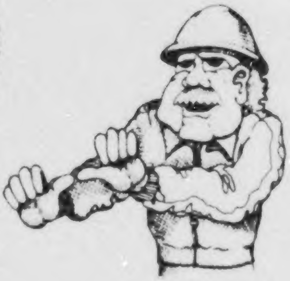
a. __________________ b. __________________ c. __________________



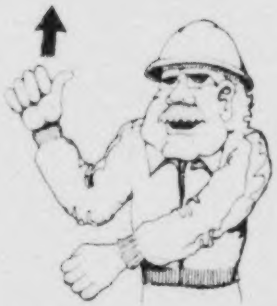
d. ________________



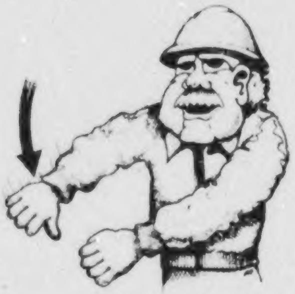
e. ________________



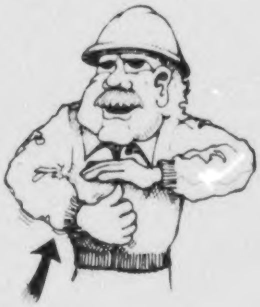
f. ________________



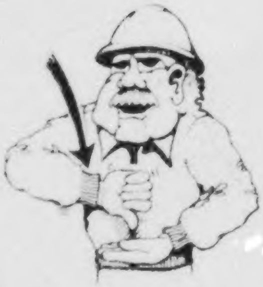
g. ________________



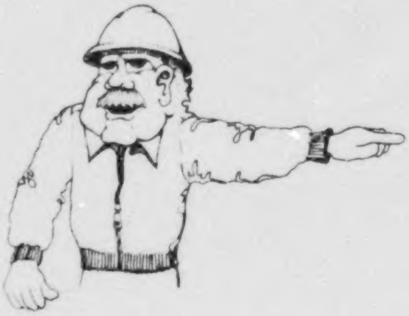
h. ________________



i. ________________

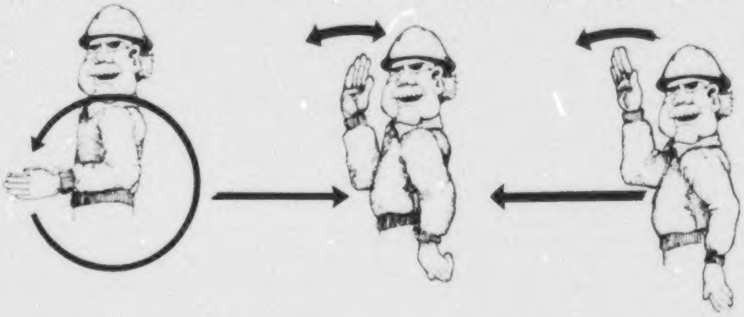


j. ________________

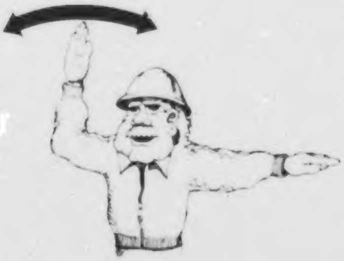


k. ________________

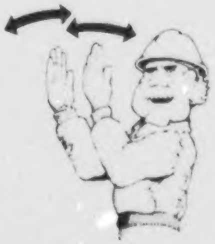
8. Identify the following hand signals used when maneuvering vehicles.



a. ______________________

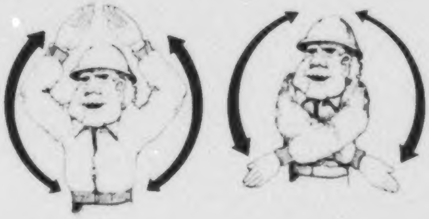


b. ______________________

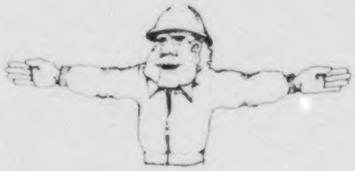


c. ______________________

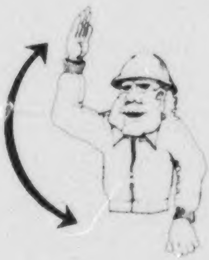
9. Identify the following line work signals.



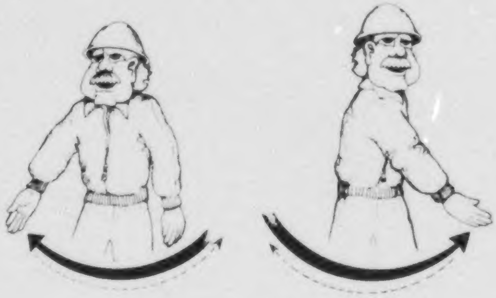
a. ______________________



b. ______________________



c. ______________________



d. ______________________

10. Select from the following list the proper radio procedures.

______a. Keep message as brief and precise as possible

______b. Call the base station by giving your unit number and the call letters of the base station

______c. Hold microphone twelve to eighteen inches from mouth

______d. Give your call letters and unit number and the unit number you are calling

______e. Clear the air when message is complete by giving unit call letters and unit number

______f. Speak clearly in normal voice tone and volume

______g. Receive calls from other units or the base station by giving your unit number

______h. Hold microphone three to four inches from mouth

11. State emergency radio procedure.

a. ____

b. ____

c. ____

12. Select from the following list the prohibited uses of the two-way radio.

______a. Selling something

______b. Interference with other communications

______c. Unnecessary or personal conversations

______d. Calls to or conversations with stations other than your own

______e. Routine business messages

______f. Music or sound effects

______g. Obscene, profane, or indecent language

______h. Messages not directed to any one person

______i. Using messages with special meanings

______j. Relaying messages for someone other than your system units except in an emergency

13. Match the code numbers on the right to the correct meanings.

______a. Caution

______b. Unable to copy; change location

______c. Signal good

______d. Acknowledgement

______e. Relay

______f. Busy; stand by unless urgent

______g. Out of service (give location and/or telephone number)

______h. In service

______i. Repeat

______j. Stand by (stop)

______k. Location

______l. Call . . . by telephone

______m. Disregard

______n. Arrived at scene

______o. Assignment completed

______p. Report in person to (meet) . . .

______q. Illegal use of radio

______r. Beginning tour of duty

______s. Ending tour of duty

______t. Wrecker needed

______u. Ambulance needed

______v. Message cancellation

______w. Dispatch information

______x. Message received

______y. Negative

______z. In contact with

1. 10-1
2. 10-4
3. 10-5
4. 10-0
5. 10-2
6. 10-21
7. 10-52
8. 10-6
9. 10-68
10. 10-7
11. 10-74
12. 10-69
13. 10-12
14. 10-75
15. 10-9
16. 10-23
17. 10-8
18. 10-20
19. 10-24
20. 10-51
21. 10-30
22. 10-41
23. 10-22
24. 10-66
25. 10-25
26. 10-42

____aa. En route

____bb. ETA (estimated time of arrival)

____cc. Need assistance

____dd. If meeting . . . advise ETA

____ee. Check (test) signal

____ff. Emergency situation

27. 10-84
28. 10-76
29. 10-77
30. 10-33
31. 10-97
32. 10-78

COMMUNICATIONS
UNIT II

ANSWERS TO TEST

1. List four types of necessary communications for an REC employee.

   a. Verbal

   b. Hand signals

   c. Radio

   d. Written

2. Select from the following list the items of communication that are important between fellow workers.

   a. Pole buddy or other crew members

      _X_ 1) What you are doing

      ____ 2) When lunch time is

      _X_ 3) What your buddy's position is in relation to energized conductors or unsafe conditions

   b. Other crews

      _X_ 1) Where you are

      _X_ 2) What you are doing

      ____ 3) What time it is

   c. Radio dispatcher

      _X_ 1) When you are going to be away from your radio

      _X_ 2) When you arrive at a job site

      _X_ 3) When you leave a job site

      ____ 4) When you leave on vacation

3. List four items of communication that are important between the worker and the supervisor.

   (NOTE: Any four of the following are acceptable.)

   a. Worker's responsibility

   b. Supervisor's responsibility

c. Worker's authority

d. Supervisor's authority

e. Unsafe conditions of tools and equipment

f. Unsafe acts

g. All accidents

4. Select from the following list items of communication that are important between the worker and the general public.

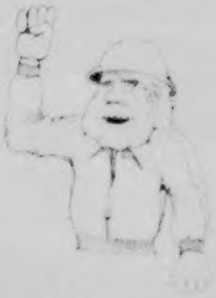
X a. Programs of your organization

X b. Hazards to the public at job site

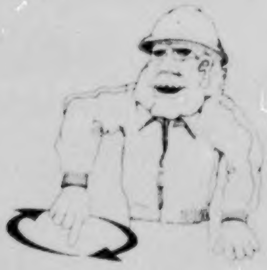
X c. Purpose of your organization

d. Responsibilities of your job

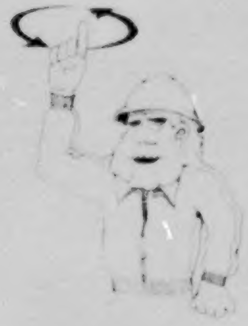
5. Identify the following hoist signals.



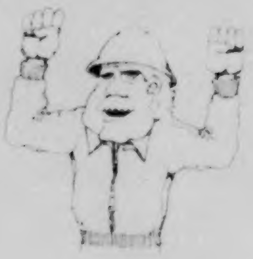
a. Stop



b. Lower the load

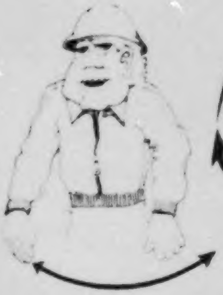


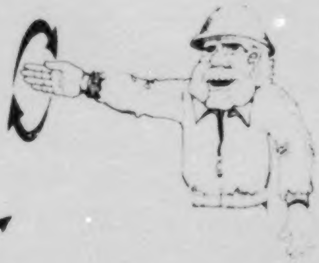
c. Raise the load

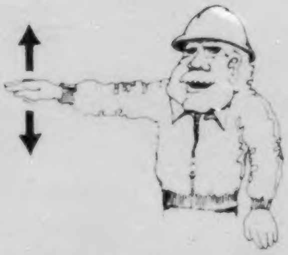


d. Emergency stop

6. Identify the following winch line signals.

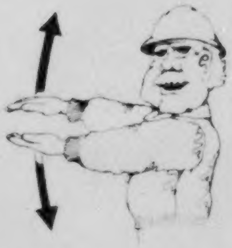




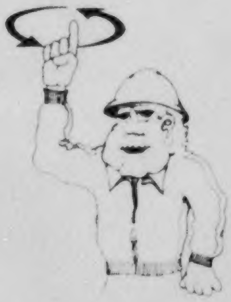


a. Pull

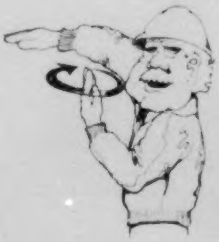
b. Lower



c. Slack off slow or lower a little

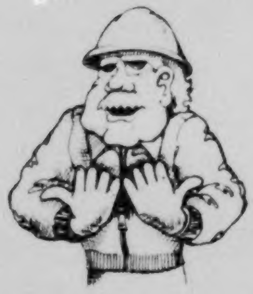


d. Hoist

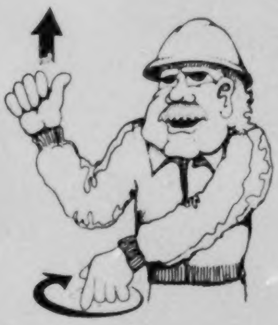


e. Take up slow or raise a little

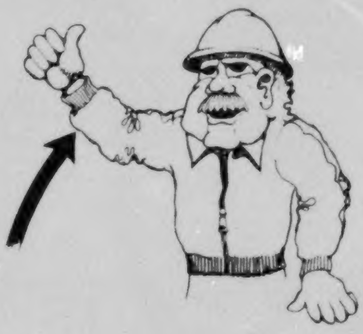
7. Identify the following hand signals used in boom operations.



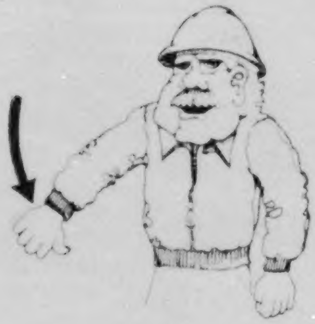
a. Crowd or extend



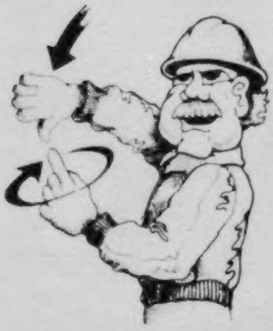
b. Raise boom, lower load



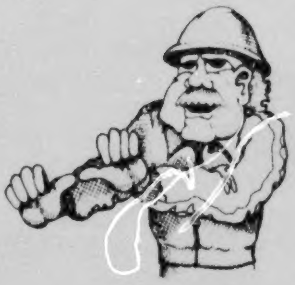
c. Raise boom



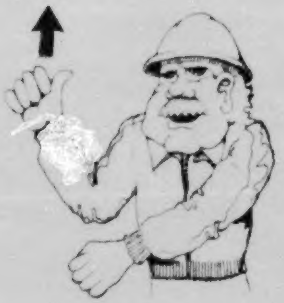
d. Lower boom



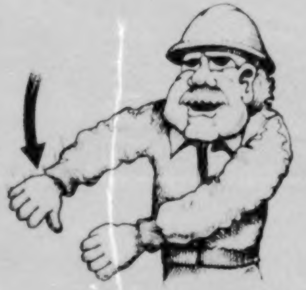
e. Lower boom, raise load



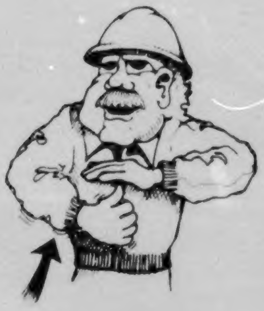
f. Rehaul or retract



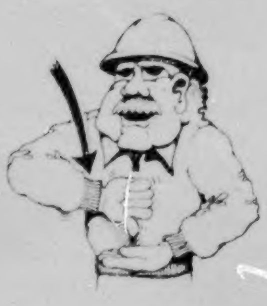
g. Raise boom, hold load



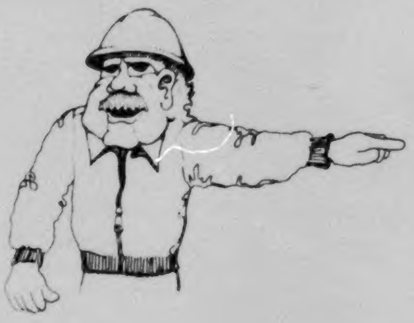
h. Lower boom, hold load



i. Raise boom slowly

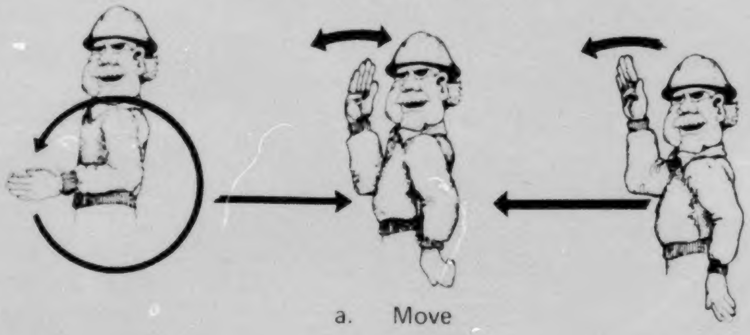


j. Lower boom slowly

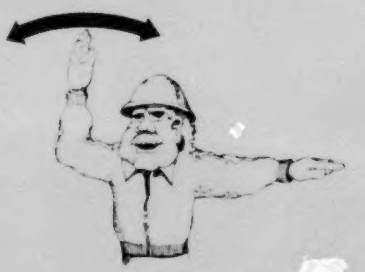


k. Swing in direction finger points

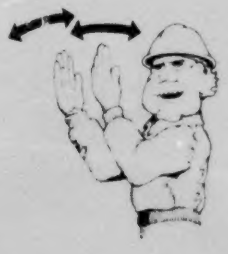
8. Identify the following hand signals used when maneuvering vehicles.



a. Move

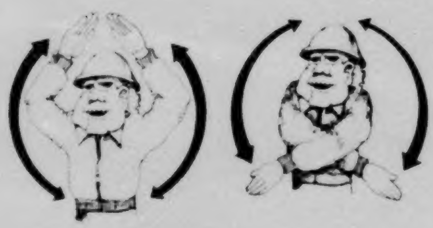


b. Turn while moving

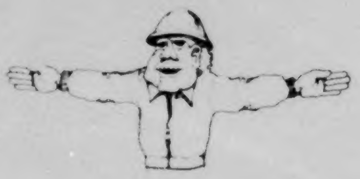


c. Straighten out

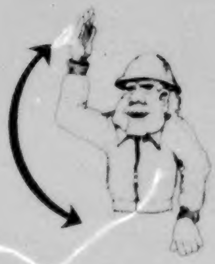
9. Identify the following line work signals.



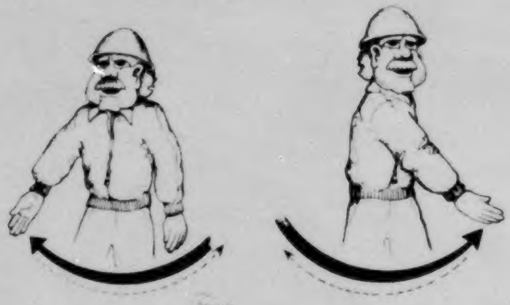
a. All off



b. Stop



c. Pull up wire



d. Slack back

10. Select from the following list the proper radio procedures.

X a. Keep message as brief and precise as possible

X b. Call the base station by giving your unit number and the call leters of the base station

____ c. Hold microphone twelve to eighteen inches from mouth

X d. Give your call letters and unit number and the unit number you are calling

X e. Clear the air when message is complete by giving unit call letters and unit number

X f. Speak clearly in normal voice tone and volume

____ g. Receive calls from other units or the base station by giving your unit number

X h. Hold microphone three to four inches from mouth

11. State emergency radio procedure.

a. Have necessary information ready

1) Location

2) Type of accident or emergency

3) Type of assistance needed

b. Call dispatcher and give information

c. Wait for verification

12. Select from the following list the prohibited uses of the two-way radio.

X a. Selling something

X b. Interference with other communications

X c. Unnecessary or personal conversations

X d. Calls to or conversations with stations other than your own

____ e. Routine business messages

X f. Music or sound effects

X g. Obscene, profane, or indecent language

X h. Messages not directed to any one person

X i. Using messages with special meanings

X j. Relaying messages for someone other than your system units except in an emergency

13. Match the code numbers on the right to the correct meanings.

4 a. Caution

1 b. Unable to copy; change location

5 c. Signal good

2 d. Acknowledgement

3 e. Relay

8 f. Busy; stand by unless urgent

10 g. Out of service (give location and/or telephone number)

17 h. In service

15 i. Repeat

13 j. Stand by (stop)

18 k. Location

6 l. Call . . . by telephone

23 m. Disregard

16 n. Arrived at scene

19 o. Assignment completed

25 p. Report in person to (meet) . . .

21 q. Illegal use of radio

22 r. Beginning tour of duty

26 s. Ending tour of duty

20 t. Wrecker needed

7 u. Ambulance needed

1. 10-1
2. 10-4
3. 10-5
4. 10-0
5. 10-2
6. 10-21
7. 10-52
8. 10-6
9. 10-68
10. 10-7
11. 10-74
12. 10-69
13. 10-12
14. 10-75
15. 10-9
16. 10-23
17. 10-8
18. 10-20
19. 10-24
20. 10-51
21. 10-30

24	v.	Message cancellation	22.	10-41
9	w.	Dispatch information	23.	10-22
12	x.	Message received	24.	10-66
11	y.	Negative	25.	10-25
14	z.	In contact with	26.	10-42
28	aa.	En route	27.	10-84
29	bb.	ETA (estimated time of arrival)	28.	10-76
32	cc.	Need assistance	29.	10-77
27	dd.	If meeting . . . advise ETA	30.	10-33
31	ee.	Check (test) signal	31.	10-97
30	ff.	Emergency situation	32.	10-78

BASIC ELECTRICAL THEORY
UNIT III

UNIT OBJECTIVE

After completion of this unit, the student should be able to identify types and conditions of circuits, discuss the theory of magnetism, and name sources of alternating and direct current. The student should be able to discuss the electron theory and calculate problems dealing with Ohm's law. This knowledge will be evidenced by scoring 85 percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms associated with basic electrical theory to the correct definitions.
2. List uses of electricity.
3. Discuss in a short paragraph the electron theory.
4. Distinguish between alternating and direct current.
5. Match types of magnets to the correct descriptions.
6. State the law of magnetic poles.
7. Describe magnetic force as it relates to production of electricity.
8. Select from a list characteristics of electromagnetic force.
9. Explain the generation of electricity using magnets.
10. Describe electromagnetic induction.
11. Identify types of circuits.
12. Identify conditions of circuits.
13. Name sources of alternating and direct current.
14. Identify divisions of an electrical system.
15. State the relationship of amperage, resistance, and voltage.
16. Calculate problems dealing with Ohm's law.

BASIC ELECTRICAL THEORY
UNIT III

SUGGESTED ACTIVITIES

I. Suggested activities for instructor:

   A. Provide student with objective sheet.

   B. Provide student with information and assignment sheets.

   C. Make transparencies.

   D. Discuss unit and specific objectives.

   E. Discuss information and assignment sheets.

   F. Work problems using Ohm's law.

   G. Show student charts, films, and other supplemental material on electrical theory.

   H. Give test.

II. Unit references:

   A. Turner, J. Howard, ed. *Understanding Electricity and Electrical Terms.* rev. Athens, Georgia: AAVIM, 1974.

   B. Parady, W. Harold, and Turner, J. Howard. *Electric Energy*. Athens, Georgia: AAVIM, 1976.

BASIC ELECTRICAL THEORY
UNIT III

INFORMATION SHEET

I. Terms and definitions

   A. Electricity--Energy that can easily be converted into light, heat, and power

   B. Ampere--Unit of measure used to determine current flow through a conductor

   C. Volt--Unit of measure of electromotive force

   D. Watt--Unit of measure used to determine the rate of energy supplied

   E. Watt-hour--One watt for one hour

   F. Kilowatt (kW)--One thousand (1000) watts

   G. Megawatt (mW)--One million (1,000,000) watts

   H. Gigawatt (GW)--One billion (1,000,000,000) watts

   I. Kilowatt-hour (kW·h)--1000 watts for 1 hour

   J. Horsepower--Unit of mechanical power equal to 746 watts of electrical power

   K. Direct current (DC)--Current that flows in one direction at a continuous rate

   L. Alternating current (AC)--Current that reverses flow from positive to negative and back to positive at regular intervals

      (NOTE: Sixty-cycle current reverses flow 120 times per second.)

   M. Circuit--Path through which electricity flows

   N. Switch--Device used to open or close a circuit

   O. Circuit breaker--Device used to open a circuit when current flow is too great

      (NOTE: Circuit breakers may be reset when they have cooled.)

   P. Fuse--Device used to open a circuit by burning out when current flow becomes too great

   Q. Conductor--Any substance through which electrical current can flow easily

      Example: Wires used in electrical circuits

INFORMATION SHEET

R. Insulation--Any substance which will not allow the flow of electrical current in any measurable amount

Example: The covering on electrical conductors

S. Hot wire--Slang for an electrically energized conductor

T. Potential--Presence of voltage in a conductor

(NOTE: Any conductive substance which has a potential will indicate a voltage differential between the substance and ground or another conductor.)

U. Ground--Point of connection of a conductor to assist returning current flow to return to the source or to equalize potential

V. Neutral--Current-carrying conductor that is connected to a ground

W. Common--Current-carrying conductor which may or may not be grounded

X. Hertz--One complete reversal of alternating current from positive to negative and back to positive

(NOTE: The term *hertz* has the same meaning as *cycle*.)

II. Uses of electricity

A. Light

B. Heat

C. Cooling

D. Power

E. Communications

F. Control

III. Electron theory

A. All things are made of atoms

B. Atoms contain protons and electrons

1. Nucleus is made up of one or more protons

2. Electrons orbit the nucleus

C. Electrons in outer orbit of atoms may move from one atom to another

INFORMATION SHEET

- D. Voltage applied to a conductor causes electrons to move in a closed circuit
- E. Electron movement in a conductor is current flow

IV. Characteristics of current

- A. Alternating current
  - 1. Reverses direction of flow at regular intervals
  - 2. Transforms easily to higher or lower voltage
  - 3. Produces an alternating magnetic field
- B. Direct current
  - 1. Flows in one direction only
  - 2. Does not transform easily

V. Types of magnets

- A. Natural--Lodestone
- B. Artificial--Magnet made of iron, nickel, cobalt, or other metals
- C. Electromagnet--Magnet made with a coil of copper wire wound on a special steel or iron core

VI. Law of magnetic poles--Unlike poles attract; like poles repel

(NOTE: All magnets have a north and south pole.)

VII. Magnetic force (Transparency 1)

- A. Surrounds a magnet
- B. Flows from north pole to south pole
- C. Generates electricity when a bar magnet is moved in and out of a coil of wire
- D. Produces electricity when a conductor cuts the lines of magnetic force

VIII. Characteristics of electromagnetic force

- A. A magnetic field is created around a current-carrying conductor
- B. Electromagnetic force increases as current flow increases
- C. An iron or steel core inside an energized coil will increase the electromagnetic force by concentrating the lines of force

INFORMATION SHEET

IX. Generation of electricity

- A. Occurs when a magnet is moved close to a coil
- B. Occurs when a coil is moved close to a magnet
- C. Occurs when a strong bar magnet is moved in and out of a coil (Transparency 2)

X. Electromagnetic induction

- A. Voltage will be induced in a conductor that moves across an electromagnetic field

  (NOTE: Either the conductor or the magnetic field may move to cause electromagnetic induction.)

- B. Voltage will be induced in a coil when changing current is applied to an adjacent coil

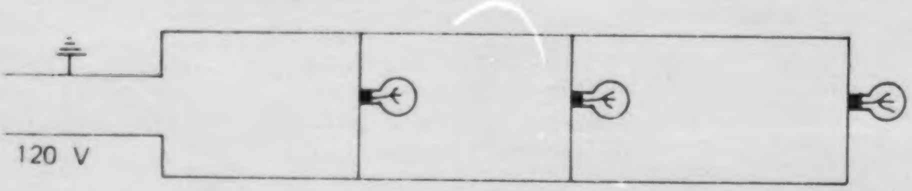
  (NOTE: Voltage will be induced in a conductor which runs parallel to an energized conductor and is close enough to the energized conductor to be in the magnetic field which surrounds it.)

XI. Types of circuits

- A. Parallel circuit (Transparency 3)

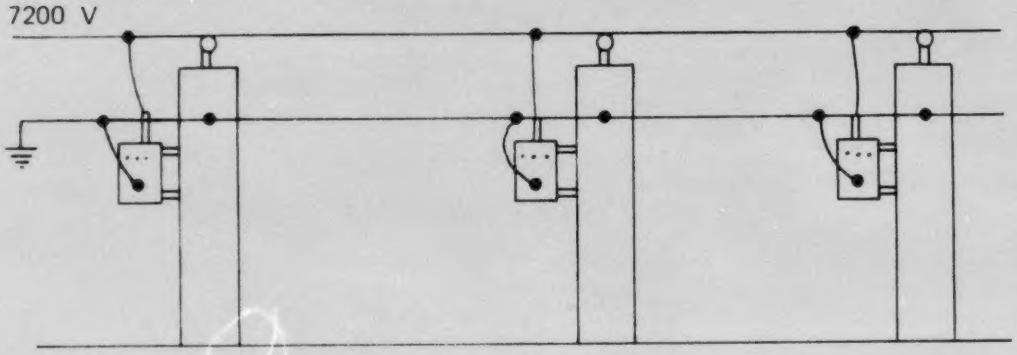
  (NOTE: The voltage will be the same at all points along a parallel circuit.)

  1. Low voltage



INFORMATION SHEET

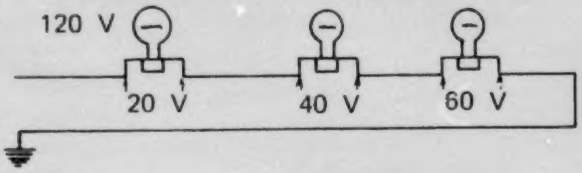
2. High voltage



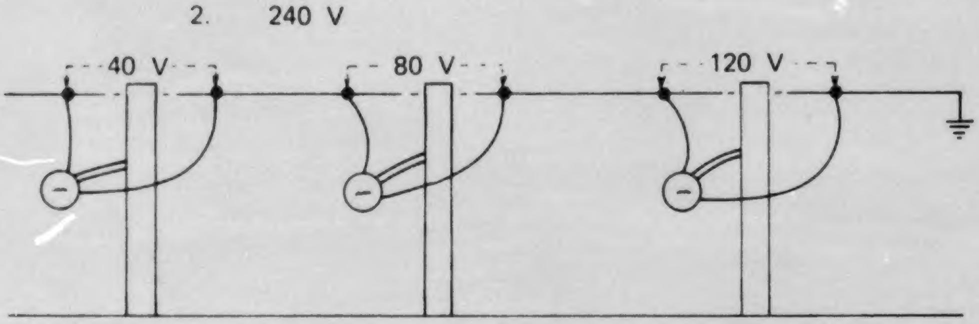
B. Series circuit (Transparency 4)

(NOTE: In a series circuit the voltage will drop along the circuit. The total voltage drop in a series circuit will always be equal to the applied voltage.)

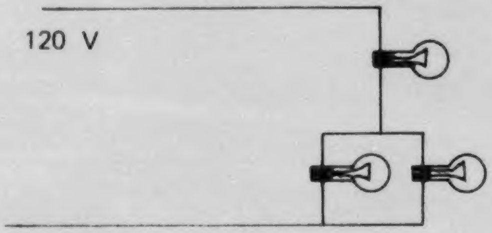
1.



2.



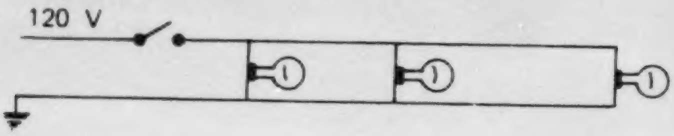
C. Series-parallel circuit (Transparency 4)



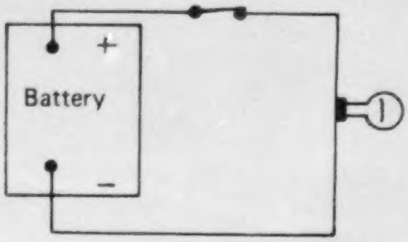
INFORMATION SHEET

XII. Conditions of circuits (Transparency 5)

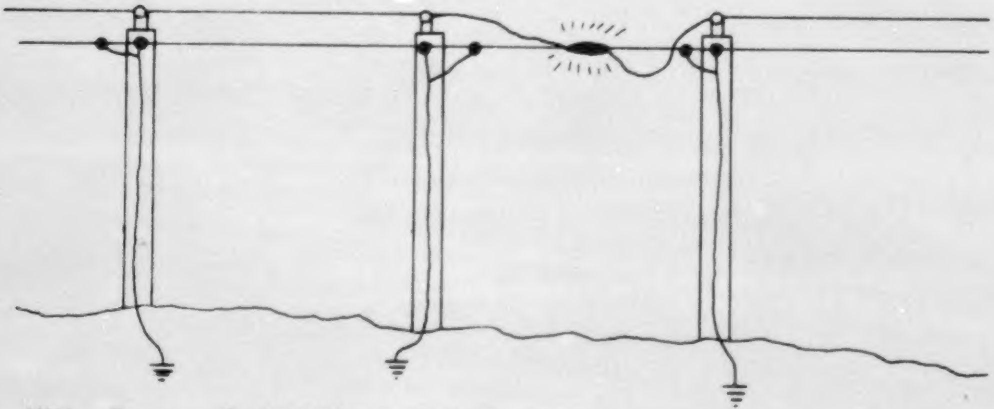
A. Open circuit



B. Closed circuit



C. Shorted circuit



XIII. Sources of alternating and direct current

A. Alternating current

1. Generators
2. Alternators

B. Direct current

1. Generators
2. Batteries
3. Solar cells

INFORMATION SHEET

XIV. Divisions of electrical system (Transparency 6)

- A. Generation plant
- B. Transformer
- C. Transmission lines
- D. Substation
- E. Distribution lines
- F. Secondary lines
- G. Service lines
- H. Distribution transformer
- I. Meter pole

XV. Relationship of amperage, resistance, and voltage--One volt will push one ampere through one ohm of resistance

XVI. Calculating problems using Ohm's law (Transparency 7)

(NOTE: In the formula of Ohm's law, I = Amperage, E = Voltage, R = Resistance, and P = Wattage.)

A. To find voltage when amperage and resistance are stated (Assignment Sheet #1)

Voltage = Amperage x Resistance

Example:
E = I x R
E = 10 amperes x 12 ohms
E = 120 volts

B. To find amperage (Assignment Sheet #2)

1. When voltage and resistance are stated

Amperage = Voltage ÷ Resistance

Example:
I = E ÷ R
I = 120 volts ÷ 12 ohms
I = 10 amperes

2. When current rating is stated in watts

Amperage = Wattage ÷ Voltage

Example:
I = P ÷ E
I = 1440 watts ÷ 120 volts
I = 12 amperes

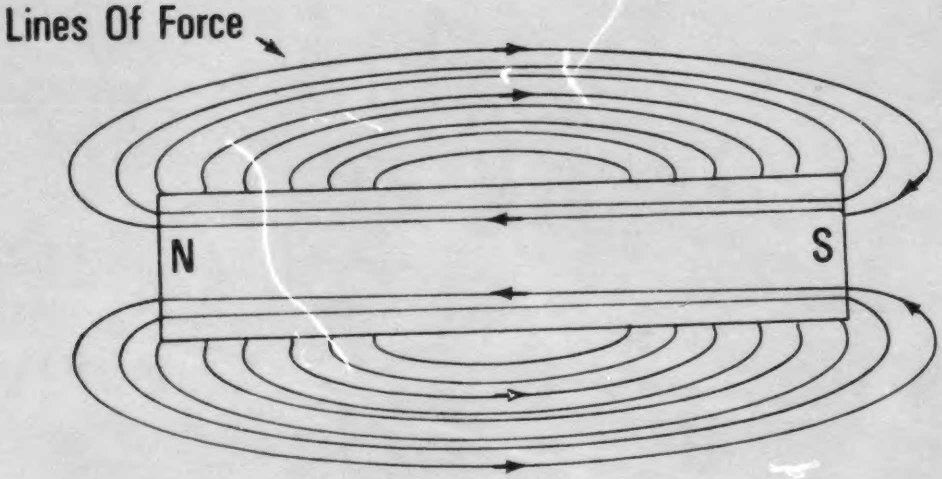
INFORMATION SHEET

C. To find resistance when voltage and amperage are stated (Assignment Sheet #3)

Resistance = Voltage ÷ Amperage

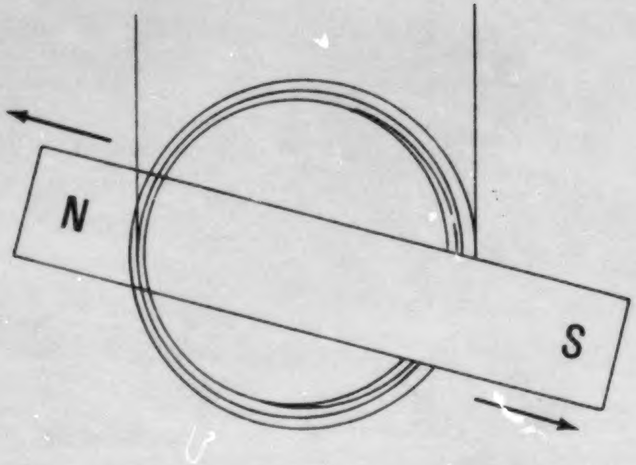
Example: R = E ÷ I
R = 120 volts ÷ 10 amperes
R = 12 ohms

Magnetic Force



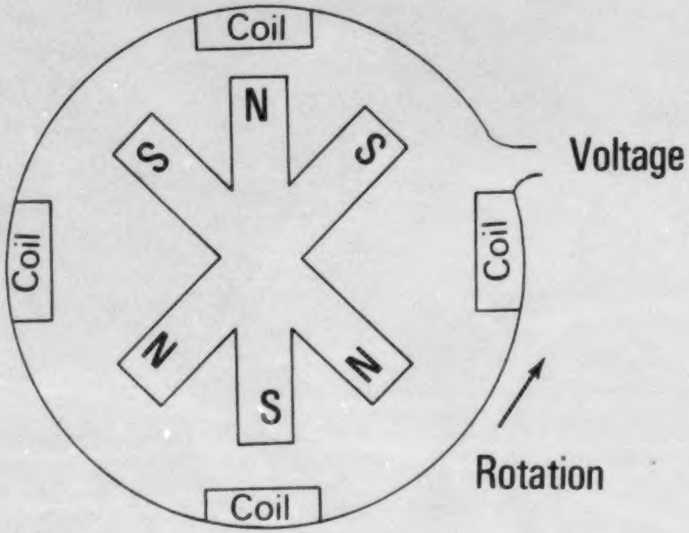
The Lines Of Force Move From The South Pole To
The North Pole Through The Magnet

Generation Of Electricity



As Magnet Moves In And Out Of Coil,

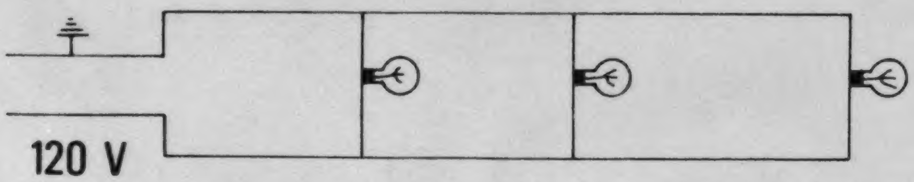
Voltage Is Created In Coil.



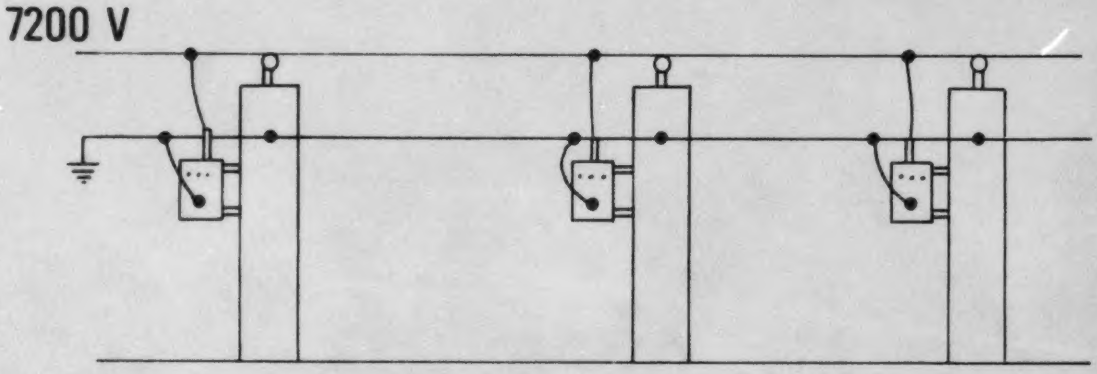
SIMPLE GENERATOR

Types Of Circuits

PARALLEL CIRCUITS



LOW VOLTAGE

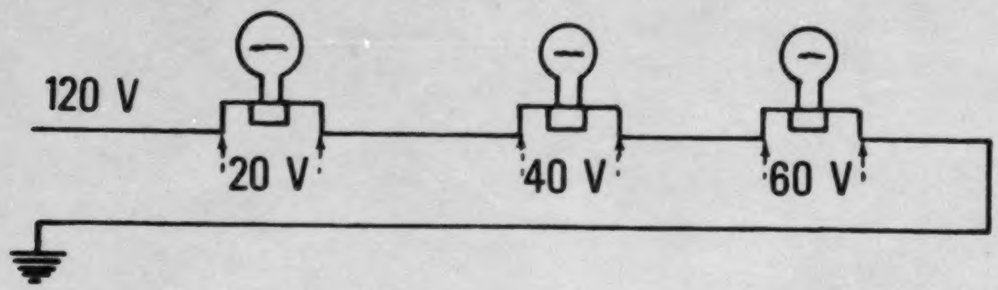


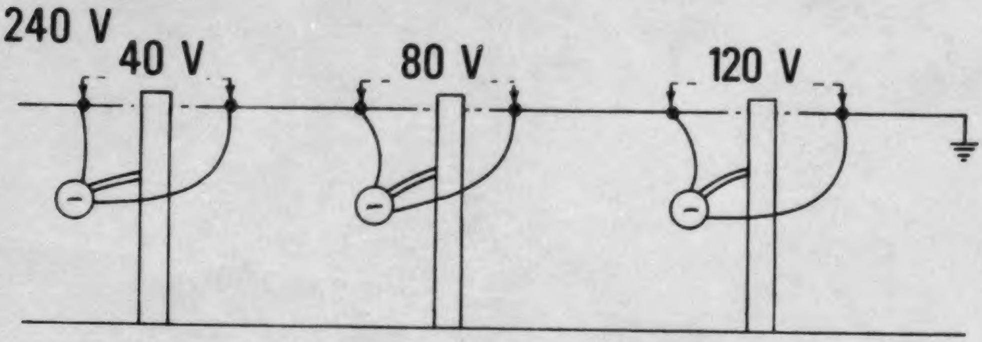
HIGH VOLTAGE

Types Of Circuits

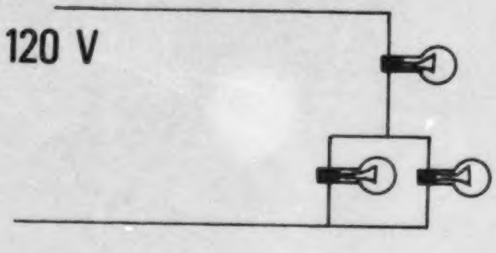
(Continued)

SERIES CIRCUITS

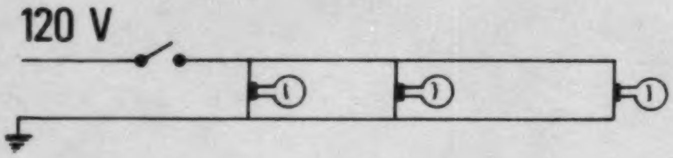




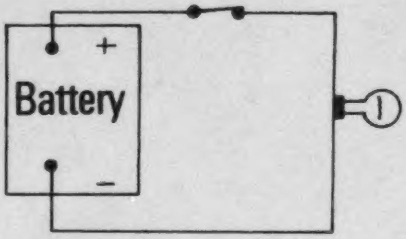
SERIES-PARALLEL CIRCUIT



Conditions Of Circuits

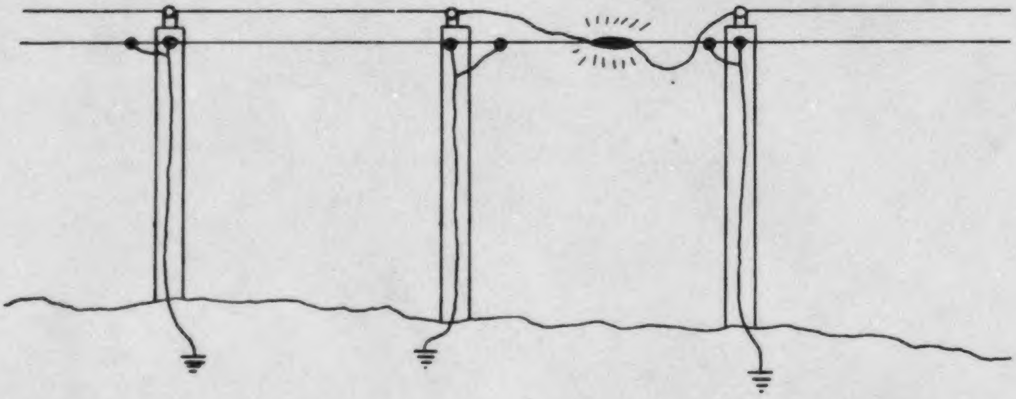


OPEN CIRCUIT

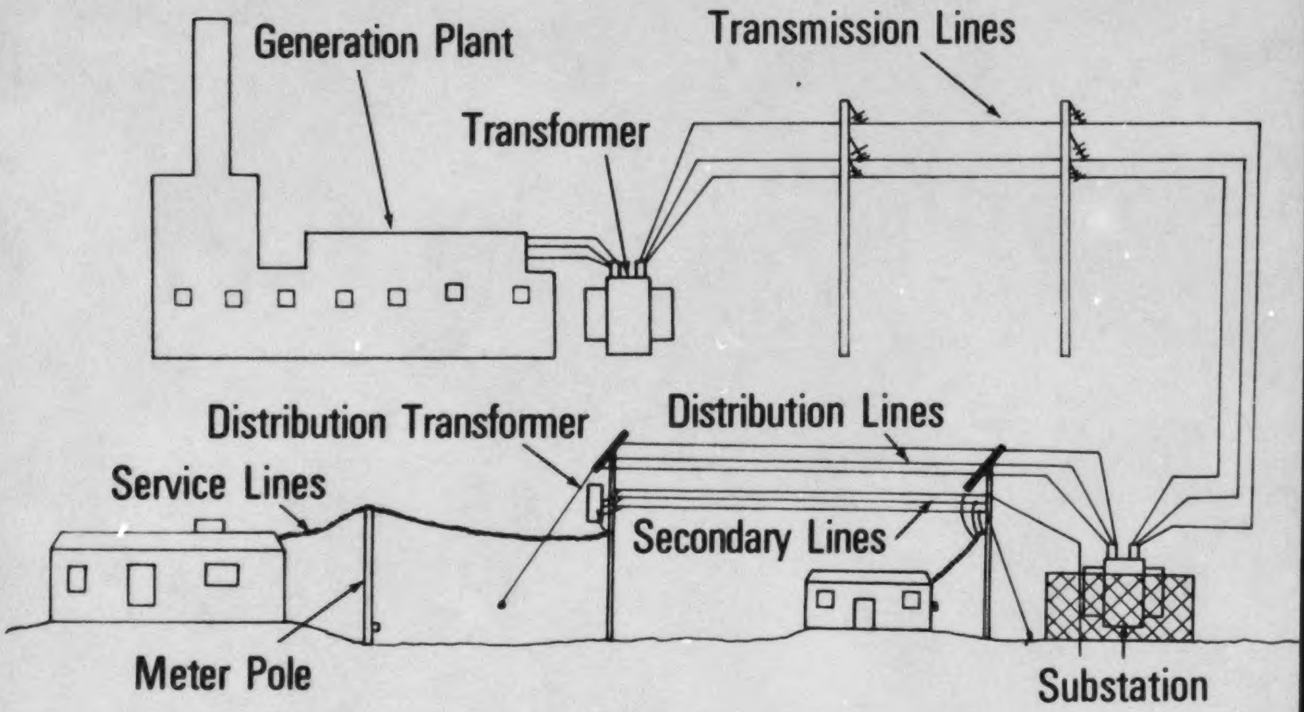


CLOSED CIRCUIT

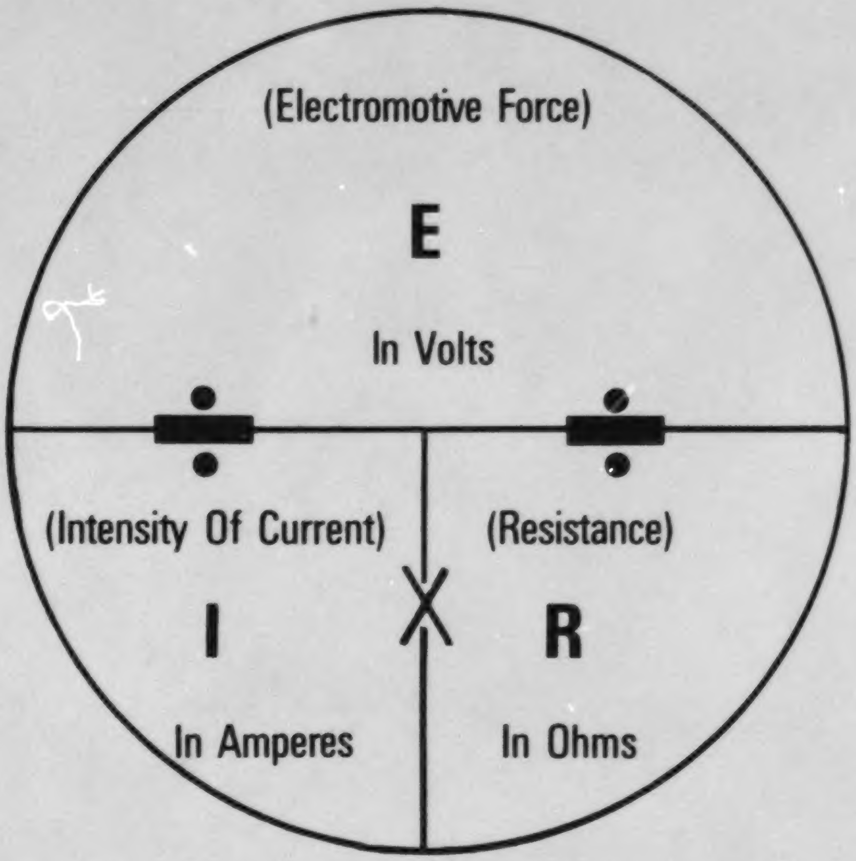
SHORTED CIRCUIT



Divisions Of Electrical System



Ohm's Law


(Electromotive Force)
E
In Volts
÷
÷
(Intensity Of Current)
I
In Amperes
X
(Resistance)
R
In Ohms

BASIC ELECTRICAL THEORY
UNIT III

ASSIGNMENT SHEET #1--SOLVE FOR AN UNKNOWN VOLTAGE

Apply the appropriate formula from Ohm's law to find the voltage.

Formula: Amps x Ohms = Volts

Examples:
2 amps x 60 ohms = 120 volts
4 amps x 120 ohms = 480 volts

Problems

	Amps	Ohms		Volts
1.	40	3	=	________
2.	10	48	=	________
3.	24	10	=	________
4.	10	120	=	________
5.	40	360	=	________

BASIC ELECTRICAL THEORY
UNIT III

ASSIGNMENT SHEET #2--SOLVE FOR AN UNKNOWN AMPERAGE

Apply the appropriate formula from Ohm's law to find the amperage.

Formula: Volts ÷ Ohms = Amps

Examples: 7200 volts ÷ 720 ohms = 10 amps
120 volts ÷ 8 ohms = 15 amps

Problems

	Volts	Ohms		Amps
1.	14,400	400	=	
2.	120	12	=	
3.	480	24	=	
4.	7,200	60	=	
5.	240	32	=	

Formula: Watts ÷ Volts = Amps

Example: 1560 watts ÷ 120 volts = 13 amps

Problems

	Watts	Volts		Amps
6.	4,800	240	=	
7.	1,560	120	=	
8.	2,400	480	=	
9.	28,800	14,400	=	
10.	3,600	7,200	=	

BASIC ELECTRICAL THEORY
UNIT III

ASSIGNMENT SHEET #3--SOLVE FOR AN UNKNOWN RESISTANCE

Apply the appropriate formula from Ohm's law to find the resistance.

Formula: Volts ÷ Amps = Ohms

Examples: 240 volts ÷ 10 amps = 24 ohms
14,400 volts ÷ 50 amps = 288 ohms

Problems

	Volts	Amps		Ohms
1.	7,200	20	=	________
2.	120	10	=	________
3.	480	3.2	=	________
4.	14,400	12	=	________
5.	240	6	=	________

BASIC ELECTRICAL THEORY
UNIT III

ANSWERS TO ASSIGNMENT SHEETS

Assignment Sheet #1

1. 120
2. 480
3. 240
4. 1200
5. 14,400

Assignment Sheet #2

1. 36
2. 10
3. 20
4. 120
5. 7.5
6. 20
7. 13
8. 5
9. 2
10. 0.5

Assignment Sheet #3

1. 360
2. 12
3. 150
4. 1200
5. 40

BASIC ELECTRICAL THEORY
UNIT III

TEST

NAME ______________________ SCORE ______________

1. Match the terms on the right to the correct definitions. (Answers to "a" through "o" are on this page.)

______a. Energy that can easily be converted into light, heat, and power

______b. Unit of measure used to determine current flow through a conductor

______c. Unit of measure of electromotive force

______d. Unit of measure used to determine the rate of energy supplied

______e. One watt for one hour

______f. 1000 watts

______g. 1,000,000 watts

______h. 1000 watts for 1 hour

______i. Unit of mechanical power equal to 746 watts of electrical power

______j. Current that flows in one direction at a continuous rate

______k. Current that reverses flow from positive to negative and back to positive at regular intervals

______l. Path through which electricity flows

______m. Device used to open or close a circuit

______n. Device used to open a circuit when current flow is too great

______o. Device used to open a circuit by burning out when current flow becomes too great

1. Circuit
2. Switch
3. Circuit breaker
4. Kilowatt (kW)
5. Horsepower
6. Fuse
7. Megawatt (mW)
8. Kilowatt-hour
9. Watt-hour
10. Direct current (DC)
11. Alternating current (AC)
12. Electricity
13. Volt
14. Ampere
15. Watt

_____p. Any substance through which electrical current can flow easily

_____q. Any substance which will not allow the flow of electrical current in any measurable amount

_____r. Slang for an electrically energized conductor

_____s. Presence of voltage in a conductor

_____t. Current-carrying conductor that is connected to a ground

_____u. Current-carrying conductor which may or may not be grounded

_____v. One complete reversal of alternating current from positive to negative and back to positive

_____w. Point of connection of a conductor to assist returning current flow to return to the source or to equalize potential

_____x. 1,000,000,000 watts

16. Conductor
17. Hertz
18. Ground
19. Neutral
20. Hot wire
21. Insulation
22. Common
23. Potential
24. Gigawatt (GW)

2. List four uses of electricity.

a. ____

b. ____

c. ____

d. ____

3. Discuss the electron theory.

____

____

____

____

____

____

____

4. Distinguish between types of current by placing an "A" in front of characteristics of alternating current and a "D" in front of direct current.

______a. Flows in one direction only

______b. Transforms easily to higher or lower voltage

______c. Reverses direction of flow at regular intervals

______d. Does not transform easily

______e. Produces an alternating magnetic field

5. Match the types of magnets on the right to the correct descriptions.

______a. Lodestone

______b. Magnet made with a coil of copper wire wound on a special steel or iron core

______c. Magnet made of iron, nickel, cobalt, or other metals

1. Natural
2. Artificial
3. Electromagnet

6 State the law of magnetic poles.

____

7. Describe magnetic force as it relates to production of electricity.

____

____

____

____

____

8. Select from the list below characteristics of electromagnetic force by placing an "X" in the blanks.

______a. A magnetic field is created around a current-carrying conductor

______b. Electromagnetic force increases as current flow increases

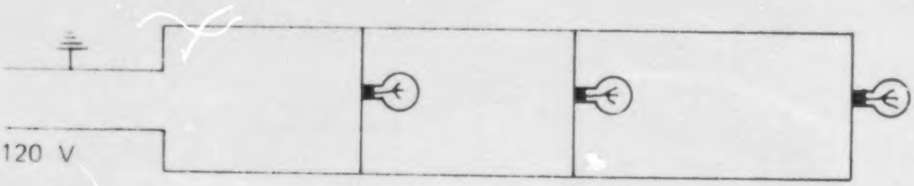
______c. Electromagnetic force is found only in a lodestone

______d. An iron or steel core inside an energized coil will increase the electromagnetic force by concentrating the lines of force

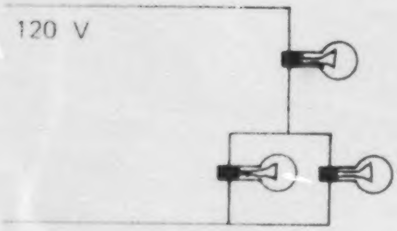
9. Explain the generation of electricity using magnets.

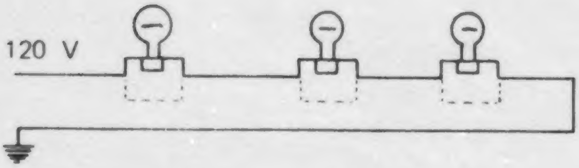
10. Describe in a short paragraph electromagnetic induction.

11. Identify the following types of circuits.



a. ______________

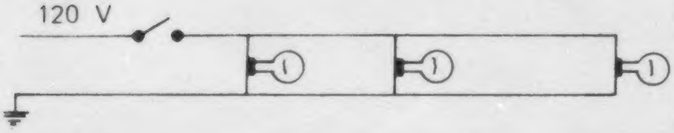


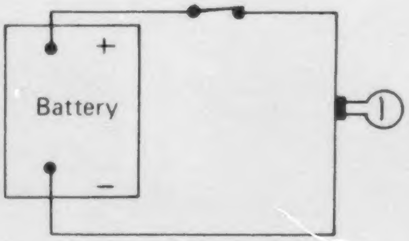


b. ______________

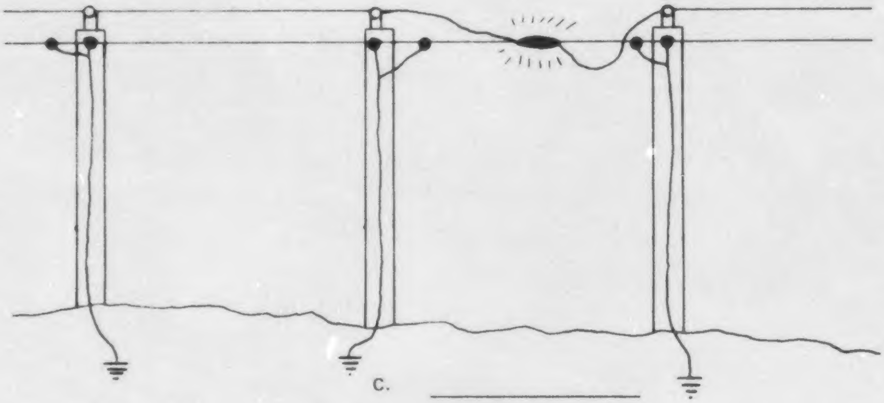
c. ______________

12. Identify the following conditions of circuits.





a. ______________ b. ______________



c. ______________

13. Name two sources of alternating current and two sources of direct current.

a. Alternating current

1) ______________________________

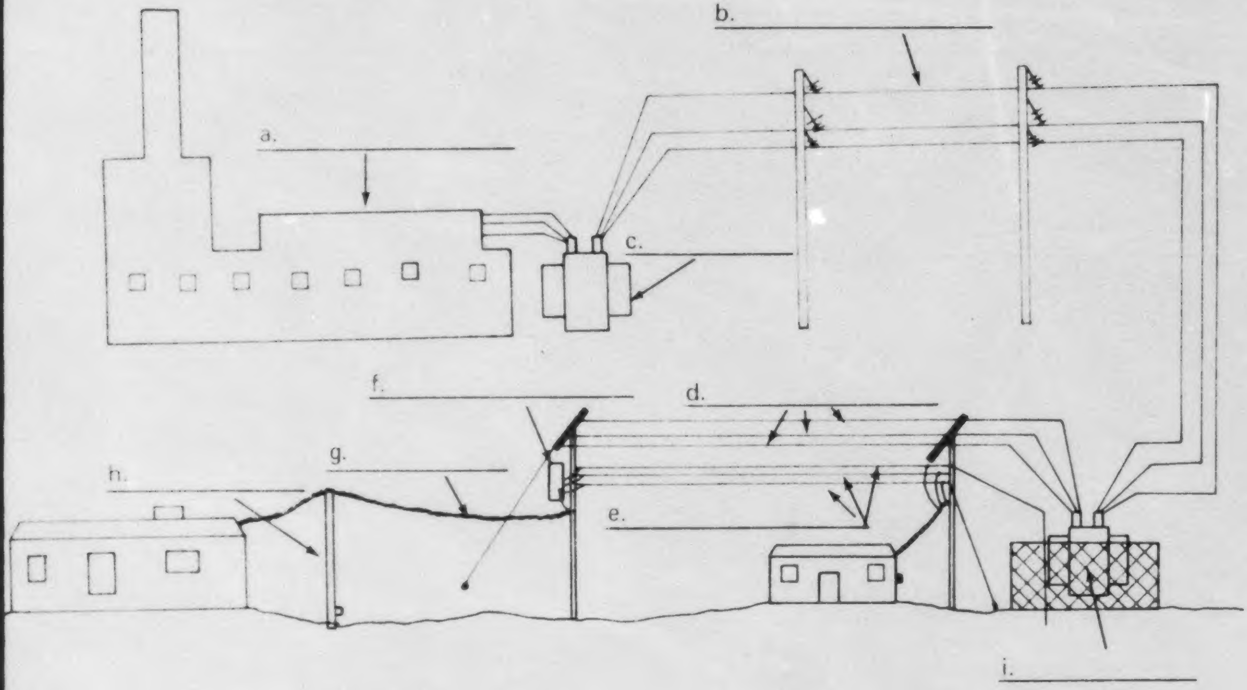
2) ______________________________

b. Direct current

1) ______________________________

2) ______________________________

14. Identify the divisions of the electrical system below by filling in the blanks.



15. State the relationship of amperage, resistance, and voltage.

____

____

16. Calculate the following problems using Ohm's law.

a. Find the voltage when:
I = 5 and R = 24 E = __________

b. Find the amperage when:
E = 240 and R = 24 I = __________

c. Find the amperage when:
P = 2880 and E = 240 I = __________

d. Find the resistance when:
E = 480 and I = 10 R = __________

BASIC ELECTRICAL THEORY
UNIT III

ANSWERS TO TEST

1. Match the terms on the right to the correct definitions.

__12__ a. Energy that can easily be converted into light, heat, and power

__14__ b. Unit of measure used to determine current flow through a conductor

__13__ c. Unit of measure of electromotive force

__15__ d. Unit of measure used to determine the rate of energy supplied

__9__ e. One watt for one hour

__4__ f. 1000 watts

__7__ g. 1,000,000 watts

__8__ h. 1000 watts for 1 hour

__5__ i. Unit of mechanical power equal to 746 watts of electrical power

__10__ j. Current that flows in one direction at a continuous rate

__11__ k. Current that reverses flow from positive to negative and back to positive at regular intervals

__1__ l. Path through which electricity flows

__2__ m. Device used to open or close a circuit

__3__ n. Device used to open a circuit when current flow is too great

__6__ o. Device used to open a circuit by burning out when current flow becomes too great

1. Circuit
2. Switch
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4. Kilowatt (kW)
5. Horsepower
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7. Megawatt (mW)
8. Kilowatt-hour
9. Watt-hour
10. Direct current (DC)
11. Alternating current (AC)
12. Electricity
13. Volt
14. Ampere
15. Watt

16 p. Any substance through which electrical current can flow easily

21 q. Any substance which will not allow the flow of electrical current in any measurable amount

20 r. Slang for an electrically energized conductor

23 s. Presence of voltage in a conductor

19 t. Current-carrying conductor that is connected to a ground

22 u. Current carrying conductor which may or may not be grounded

17 v. One complete reversal of alternating current from positive to negative and back to positive

18 w. Point of connection of a conductor to assist returning current flow to return to the source or to equalize potential

24 x. 1,000,000,000 watts

16. Conductor
17. Hertz
18. Ground
19. Neutral
20. Hot wire
21. Insulation
22. Common
23. Potential
24. Gigawatt (GW)

2. List four uses of electricity.

(NOTE: Any four of the following are acceptable.)

a. Light
b. Heat
c. Cooling
d. Power
e. Communications
f. Control

3. Discuss the electron theory.

a. All things are made of atoms
b. Atoms contain protons and electrons
    1) Nucleus is made up of one or more protons
    2) Electrons orbit the nucleus

c. Electrons in outer orbit of atoms may move from one atom to another

d. Voltage applied to a conductor causes electrons to move in a closed circuit

e. Electron movement in a conductor is current flow

4. Distinguish between types of current by placing an "A" in front of characteristics of alternating current and a "D" in front of direct current.

D a. Flows in one direction only

A b. Transforms easily to higher or lower voltage

A c. Reverses direction of flow at regular intervals

D d. Does not transform easily

A e. Produces an alternating magnetic field

5. Match the types of magnets on the right to the correct descriptions.

1 a. Lodestone

3 b. Magnet made with a coil of copper wire wound on a special steel or iron core

2 c. Magnet made of iron, nickel, cobalt, or other metals

1. Natural
2. Artificial
3. Electromagnet

6. State the law of magnetic poles.

Unlike poles attract; like poles repel

7. Describe magnetic force as it relates to production of electricity.

a. Surrounds a magnet

b. Flows from north pole to south pole

c. Generates electricity when a bar magnet is moved in and out of a coil of wire

d. Produces electricity when a conductor cuts the lines of magnetic force

8. Select from the list below characteristics of electromagnetic force by placing an "X" in the blanks.

X a. A magnetic field is created around a current-carrying conductor

X b. Electromagnetic force increases as current flow increases

______ c. Electromagnetic force is found only in a lodestone

X d. An iron or steel core inside an energized coil will increase the electromagnetic force by concentrating the lines of force

9. Explain the generation of electricity using magnets.

   a. Occurs when a magnet is moved close to a coil

   b. Occurs when a coil is moved close to a magnet

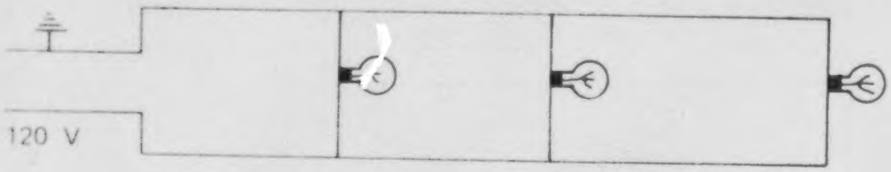
   c. Occurs when a strong bar magnet is moved in and out of a coil

10. Describe in a short paragraph electromagnetic induction.

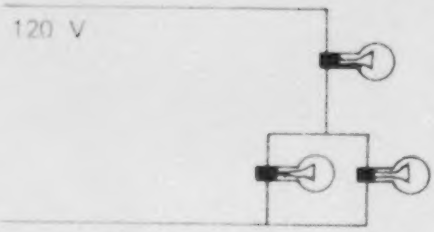
    a. Voltage will be induced in a conductor that moves across an electromagnetic field

    b. Voltage will be induced in a coil when changing current is applied to an adjacent coil

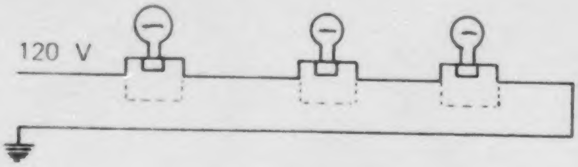
11. Identify the following types of circuits.



a. Parallel circuit

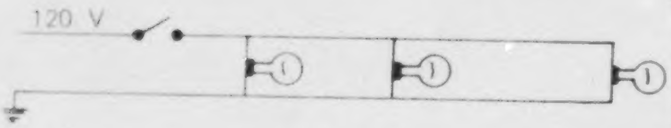


b. Series-parallel circuit

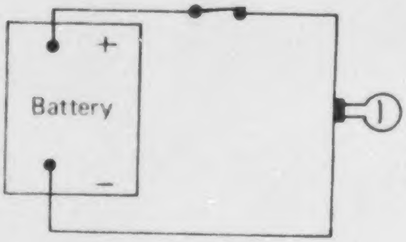


c. Series circuit

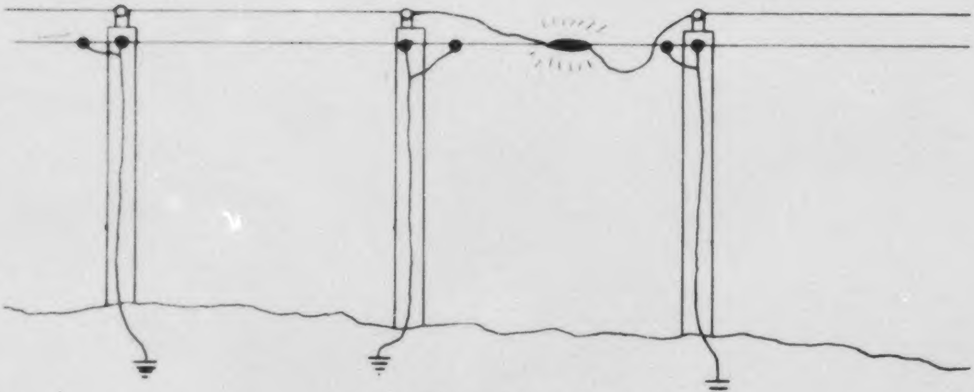
12. Identify the following conditions of circuits.



a. Open circuit



b. Closed circuit



c. Shorted circuit

13. Name two sources of alternating current and two sources of direct current.

a. Alternating current

1) Generators

2) Alternators

b. Direct current

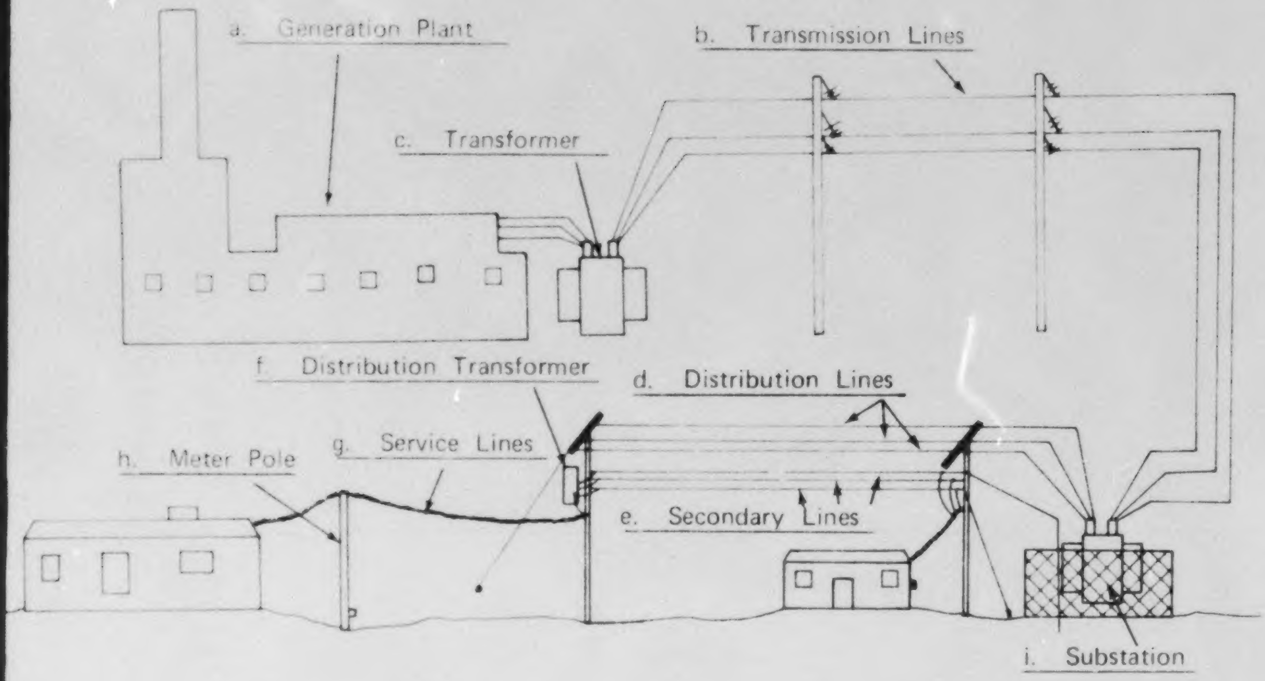
(NOTE: Any two of the following are acceptable.)

1) Generators

2) Batteries

3) Solar cells

14. Identify the divisions of the electrical system below by filling in the blanks.



15. State the relationship of amperage, resistance, and voltage.

One volt will push one ampere through one ohm of resistance

16. Calculate the following problems using Ohm's law.

a. Find the voltage when:
$I = 5$ and $R = 24$ $E = 120$

b. Find the amperage when:
$E = 240$ and $R = 24$ $I = 10$

c. Find the amperage when:
$P = 2880$ and $E = 240$ $I = 12$

d. Find the resistance when:
$E = 480$ and $I = 10$ $R = 48$

ROPE AND RIGGING
UNIT IV

UNIT OBJECTIVE

After completion of this unit, the student should be able to calculate the mechanical advantage of using block and tackle and the safe working load of various ropes. The student should be able to identify various knots and hitches. This knowledge will be evidenced by scoring 85 percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms associated with rope and rigging to the correct definitions.
2. Identify parts of a stationary block.
3. List kinds of rope used in line work.
4. Determine the tensile strength of various kinds and sizes of rope.
5. Calculate the mechanical advantage of using block and tackle.
6. List uses of various types of rope gear.
7. Calculate the safe working load of various kinds and sizes of ropes when given the tensile strength and safety factor.
8. Identify various knots and hitches.
9. Match various knots and hitches with the correct uses.
10. Identify elements of knots, bends, and hitches.
11. List conditions that damage rope.

ROPE AND RIGGING
UNIT IV

SUGGESTED ACTIVITIES

I. Suggested activities for instructor:

   A. Provide student with objective sheet.

   B. Provide student with information and assignment sheets.

   C. Make transparencies.

   D. Discuss objective sheet.

   E. Discuss information and assignment sheets.

   F. Have students practice tying various knots and hitches.

   G. Give test.

II. Unit references:

   A. Kurtz, Edwin B., and Shoemaker, Thomas M. *The Lineman's and Cableman's Handbook.* 5th ed. New York: McGraw-Hill Book Co., 1976.

   B. Rural Electrification Administration. *Specifications and Drawings for 14.4/24.9 Kv. Line Construction.* REA Form 803. rev. Washington, D.C.: U.S. Department of Agriculture, September 1969.

   C. Department of the Army. *Rigging.* TM5-725. Washington, D.C.: U.S. Army AG Publications Center, 1968.

ROPE AND RIGGING
UNIT IV

INFORMATION SHEET

I. Terms and definitions

  A. Block and tackle--Pulley or combination of pulleys operated with a rope (Transparency 1)

  B. Sheave--Grooved wheel or pulley

  C. Becket--Device to which the standing end of the rope in a block and tackle is secured

  D. Fall line--Rope to which pull is applied

  E. Hand line--Rope used with single sheave block (Transparency 1)

  F. Tag line--Rope used to hold conductors away from pole (Transparency 1)

  G. Reeve--To thread a rope around the sheaves in a set of blocks

  H. Fair lead--Use of a single line to apply pull more effectively

  I. Traveling block--End of a block and tackle which is connected to the load to be moved

  J. Tensile strength--Greatest stress a rope can bear without breaking

  K. Hitch--Knot used to temporarily secure an object

  L. Working load--Maximum load that should be applied to a rope

  M. Sling--Short piece of rope; rope whose ends have been spliced together to form an endless rope; rope with an eye in each end

II. Parts of a stationary block (Transparency 2)

  A. Safety catch

  B. Hook

  C. Outer strap

  D. Inner strap

  E. Shell

  F. Pin

INFORMATION SHEET

G. Sheaves

H. Becket

I. Thimble

(NOTE: Some blocks are made of cast aluminum or stamped steel, but the basic structure will be the same as the wooden shell block.)

III. Kinds of rope used in line work

A. Manila

B. Nylon

C. Dacron

D. Polyethylene

E. Polypropylene

IV. Size and tensile strength of new rope

Diameter	Manila	Nylon	Dacron	Poly-ethylene	Poly-propylene
3/16"	450	960	720	700	740
1/4"	600	1,500	1,150	1,200	1,250
5/16"	1,000	2,400	1,750	1,750	1,900
3/8"	1,350	3,400	2,450	2,500	2,700
7/16"	1,750	4,800	3,400	3,400	3,550
1/2"	2,650	6,200	4,400	4,100	4,500
9/16"	3,450	8,000	5,700	5,100	5,400
5/8"	4,400	10,000	7,300	6,000	6,600
3/4"	5,400	14,000	10,000	7,500	8,000
7/8"	7,700	19,000	13,600	9,900	10,750
1"	9,000	24,000	16,500	11,000	12,500
1" 1/8"	12,000	31,500	21,600	15,000	17,000
1" 1/4"	13,500	36,000	24,400	17,300	19,500

V. Calculating mechanical advantage of block and tackle (Assignment Sheet #1)

A. Count the number of sheaves in both the traveling and stationary blocks

Example: 2 sheaves (stationary block) + 2 sheaves (traveling block) = 4 sheaves

Theoretical mechanical advantage = 4 to 1

INFORMATION SHEET

B. Divide the weight to be lifted by the number of sheaves

Example: 800 lbs ÷ 4 = 200 lbs

Theoretical pull needed to lift 800 lbs = 200 lbs

C. Add 20% to the load for friction loss

Example: 20% of 800 = 160 lbs
800 + 160 = 960 lbs

D. Divide the total weight to be lifted by the number of sheaves

Example: 960 lbs ÷ 4 = 240
Actual pull needed = 240 lbs

E. Divide the actual weight to be lifted by the actual pull needed

Example: 800 ÷ 240 = 3 1/3
Actual mechanical advantage = 3 1/3 to 1

VI. Uses of rope gear (Transparency 1)

A. Block and tackle

1. Raising and lowering small transformers
2. Pulling wire
3. Lifting hot line tools
4. Lifting for general purposes

B. Sling

1. Lifting wire reels
2. Securing transformer to block and tackle
3. Securing conductor to pole
4. Lashing for general purposes

C. Hand line

1. Sending tools and small equipment to line mechanic on pole
2. Lowering tools and equipment from pole
3. Lowering line mechanic from pole in rescue situation

(CAUTION: The rope should not be tied to a vehicle that can be moved.)

INFORMATION SHEET

D. Tag line--Tying to insulating stick to hold conductor away from pole

VII. Safe working load of rope (Assignment Sheet #2)

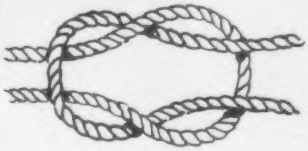
Formula: Tensile strength ÷ safety factor = working load

(NOTE: The following chart shows the working loads which may be applied to new rope. The tensile strength and working load decreases with wear.)

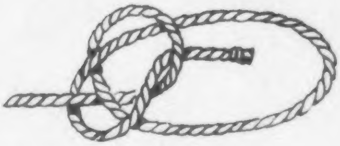
Type of Rope	Tensile Strength	Safety Factor	Working Load
1/2" nylon	6200 lbs	5	1240 lbs
1/2" polypropylene	4500 lbs	5	900 lbs
1/2" dacron	4400 lbs	5	880 lbs
1/2" polyethylene	4100 lbs	5	820 lbs
1/2" manila	2650 lbs	5	530 lbs

VIII. Knots and hitches used in line work

A. Square knot

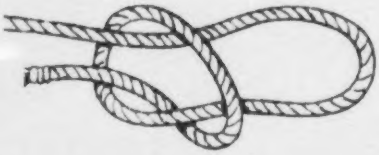


B. Bowline

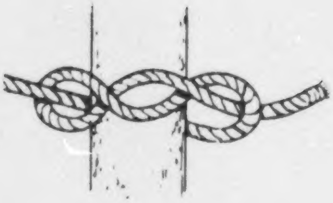


INFORMATION SHEET

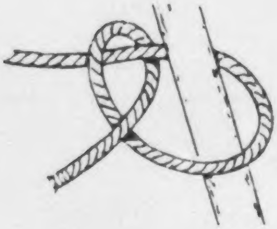
C. Slip knot



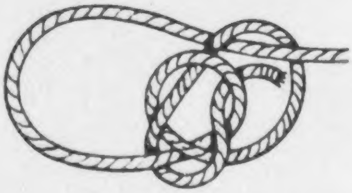
D. Timber hitch



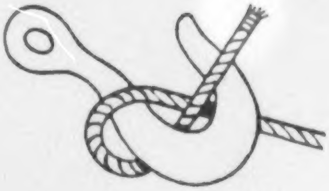
E. Half hitch



F. Running bowline

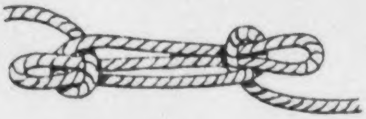


G. Blackwall hitch

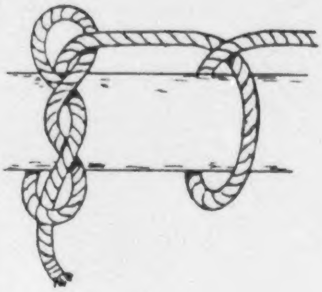


INFORMATION SHEET

H. Sheepshank



I. Timber hitch with half hitch



IX. Knots and hitches and their uses

A. Square knot--Tying sling lines

B. Bowline--Tying for general purposes

C. Slip knot--Sending tools and materials up pole

D. Timber hitch--Raising poles

E. Half hitch--Tying to poles, pipe, or arms temporarily

F. Running bowline--Guying top of pole temporarily

G. Blackwall hitch--Securing to hook while under steady strain

H. Sheepshank--Shortening rope

I. Timber hitch with half hitch--Sending crossarm up pole

X. Elements of knots, bends, and hitches (Transparency 3)

A. Bight

B. Overhand loop

C. Underhand loop

D. Running end

INFORMATION SHEET

E. Whipping

F. Round turn

G. Turn

H. Standing part

XI. Conditions that damage rope

A. Improper knots or hitches

B. Vehicle or foot traffic over rope

C. Incorrect block and sheave size

D. Overloading or sudden jerks

E. Exposure to acid, fumes, or oil

F. Dragging rope over sharp objects

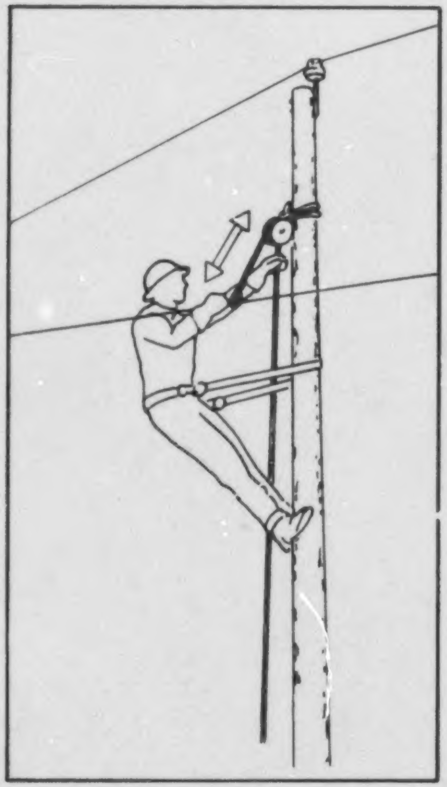
G. Permitting rope to freeze when wet

H. Exposure to extreme heat

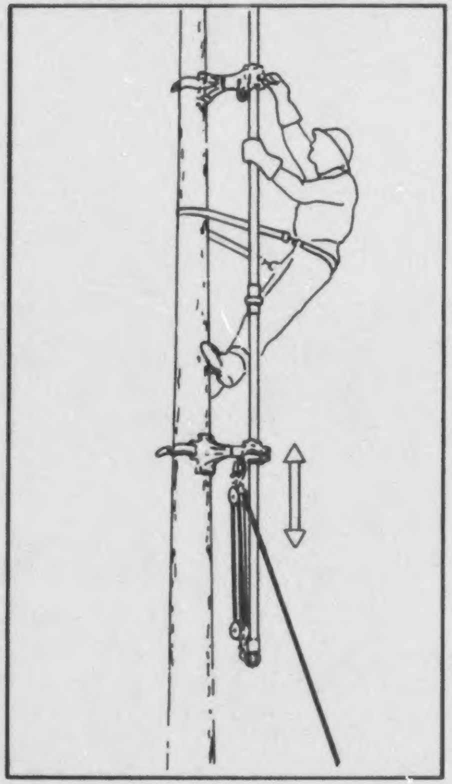
(NOTE: Manila rope is subject to mildew and rot and therefore should not be stored when wet.)

Uses of Rope Gear

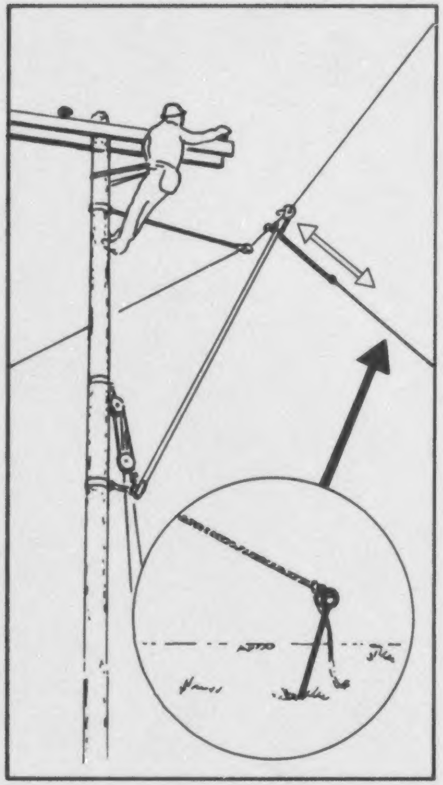
Hand Line



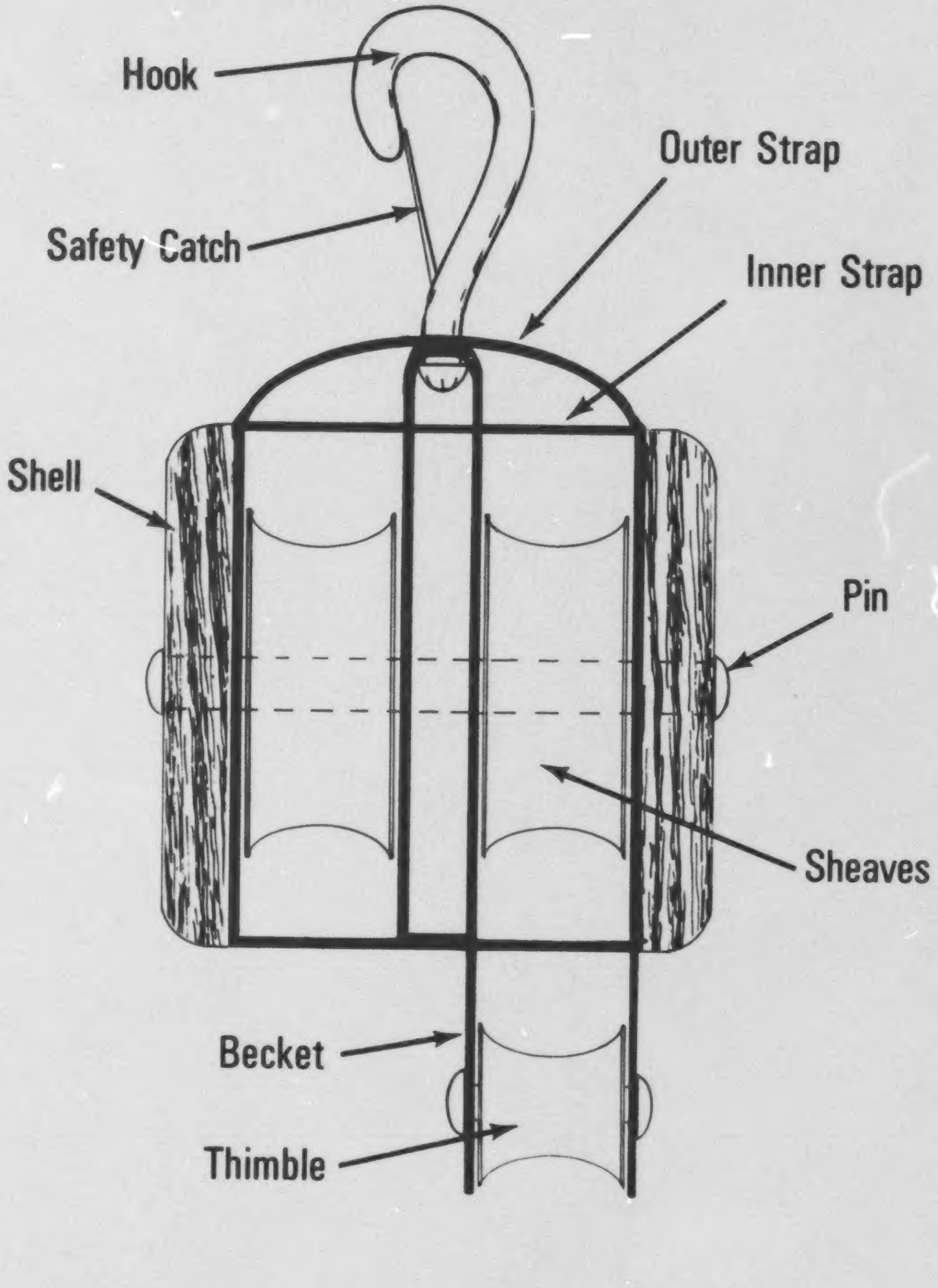
Block and Tackle



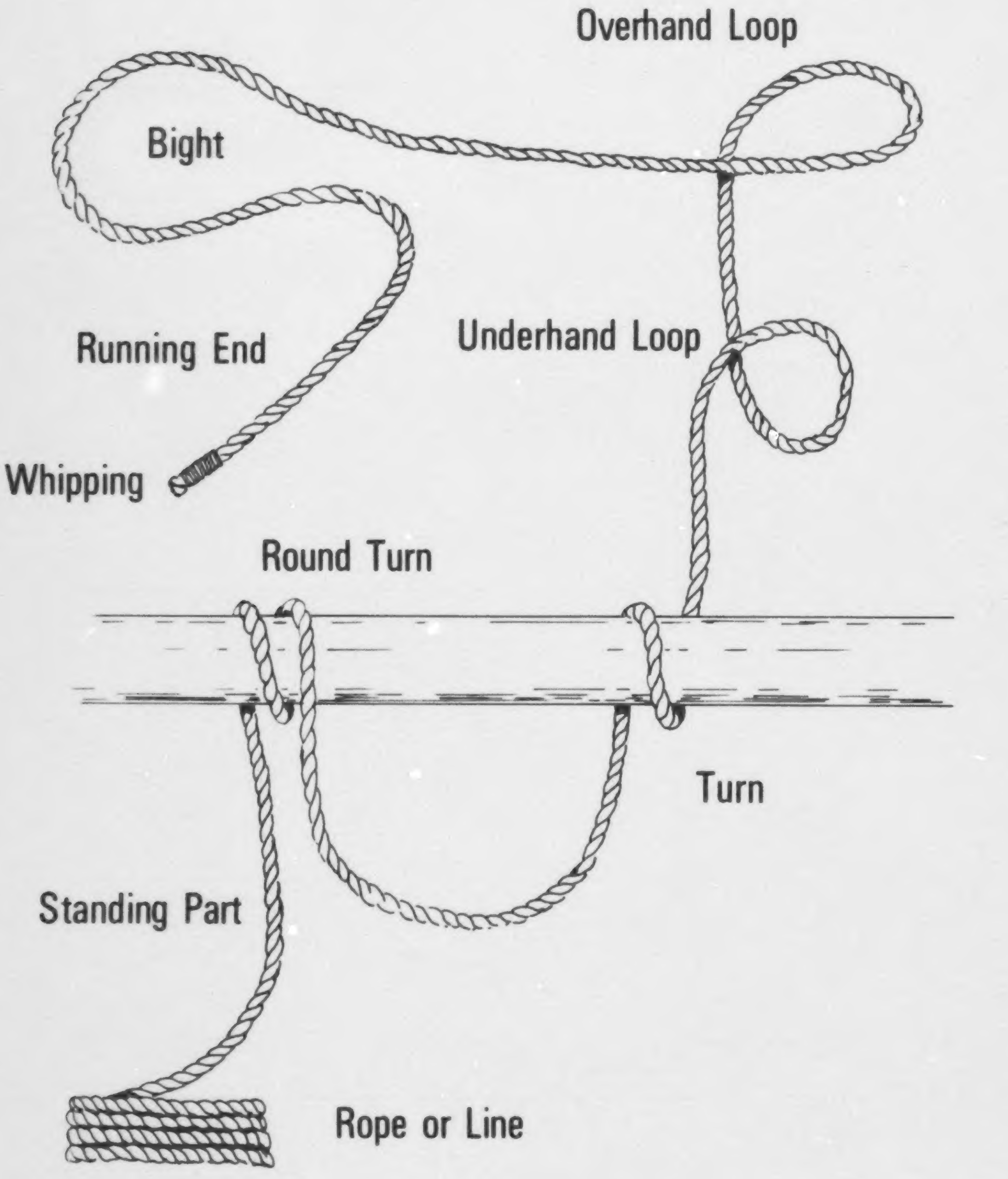
Tag Line



Parts of a Two Sheave Stationary Block



Elements of Knots, Bends, and Hitches



ROPE AND RIGGING
UNIT IV

ASSIGNMENT SHEET #1--CALCULATE THE ACTUAL MECHANICAL ADVANTAGE OF BLOCK AND TACKLE

Calculate the actual mechanical advantage of a block and tackle if the stationary block has three sheaves, the traveling block has three sheaves, and the load to be lifted weighs 600 pounds.

Total number of sheaves =
Theoretical advantage (total number of sheaves to 1) =
Theoretical pull needed (actual load ÷ total number of sheaves) =
Friction loss (20% of actual load) =
Weight to be lifted plus friction loss (actual load + 20% of actual load) =
Actual pull needed (load + friction loss ÷ number of sheaves) =

Actual mechanical advantage (actual load ÷ actual pull needed) =
Show your work.

ROPE AND RIGGING
UNIT IV

ASSIGNMENT SHEET #2--CALCULATE WORKING LOAD OF VARIOUS ROPES

Calculate the working load of the following ropes, using a safety factor of 5.

1. Polypropylene rope with 4500 lbs tensile strength

   Safe working load =

2. Nylon rope with 36,000 lbs tensile strength

   Safe working load =

3. Dacron rope with 4400 lbs tensile strength

   Safe working load =

4. Manila rope with 2650 lbs tensile strength

   Safe working load =

ROPE AND RIGGING
UNIT IV

ANSWERS TO ASSIGNMENT SHEETS

Assignment Sheet #1

Total sheaves = 6
Theoretical advantage = 6 to 1
Theoretical pull needed = 600 ÷ 6 = 100
Friction loss = 20% of 600 = 120
Weight to be lifted = 600 + 120 = 720
Actual pull needed = 720 ÷ 6 = 120
Actual mechanical advantage = actual load (600) divided by actual pull needed (120)
= 600 ÷ 120 = 5

Actual mechanical advantage = 5 to 1

Assignment Sheet #2

1. 4500 ÷ 5 = 900
2. 36000 ÷ 5 = 7200
3. 4400 ÷ 5 = 880
4. 2650 ÷ 5 = 530

ROPE AND RIGGING
UNIT IV

TEST

NAME ______________________________ SCORE ____________________

1. Match the terms on the right to the correct definitions.

_____a. Device to which the standing end of the rope in a block and tackle is secured

_____b. End of a block and tackle which is connected to the load to be moved

_____c. Greatest stress a rope can bear without breaking

_____d. Maximum load that should be applied to a rope

_____e. Rope to which pull is applied

_____f. To thread a rope around the sheaves in a set of blocks

_____g. Knot used to temporarily secure an object

_____h. Grooved wheel or pulley

_____i. Pulley or combination of pulleys operated with a rope

_____j. Short piece of rope; rope whose ends have been spliced together to form an endless rope; rope with an eye in each end

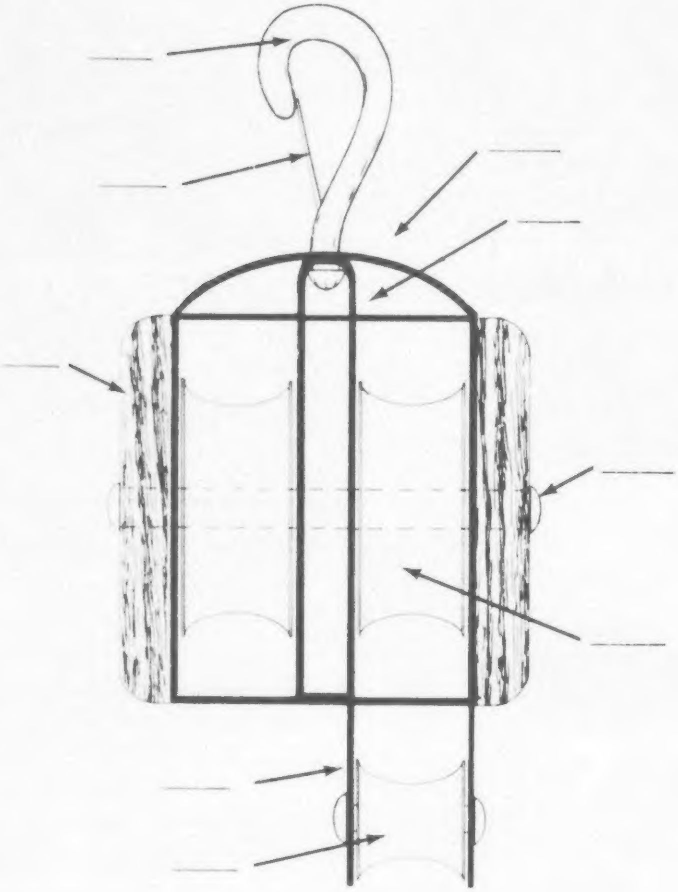
_____k. Use of a single line to apply pull more effectively

_____l. Rope used with single sheave block

_____m. Rope used to hold conductors away from pole

1. Block and tackle
2. Sheave
3. Becket
4. Fall line
5. Reeve
6. Fair lead
7. Traveling block
8. Tensile strength
9. Hitch
10. Working load
11. Sling
12. Tag line
13. Hand line

2. Identify the parts of the stationary block below by placing the correct numbers in the blanks.



1. Pin
2. Thimble
3. Shell
4. Outer strap
5. Hook
6. Becket
7. Inner strap
8. Safety catch
9. Sheaves

3. List four kinds of rope used in line work.

a. ____________

b. ____________

c. ____________

d. ____________

4. Determine the tensile strength of the following ropes by using the chart shown below.

Diameter	Manila	Nylon	Dacron	Poly-ethylene	Poly-propylene
3/16"	450	960	720	700	740
1/4"	600	1,500	1,150	1,200	1,250
5/16"	1,000	2,400	1,750	1,750	1,900
3/8"	1,350	3,400	2,450	2,500	2,700
7/16"	1,750	4,800	3,400	3,400	3,550
1/2"	2,650	6,200	4,400	4,100	4,500
9/16"	3,450	8,000	5,700	5,100	5,400
5/8"	4,400	10,000	7,300	6,000	6,600
3/4"	5,400	14,000	10,000	7,500	8,000
7/8"	7,700	19,000	13,600	9,900	10,750
1"	9,000	24,000	16,500	11,000	12,500
1" 1/8"	12,000	31,500	21,600	15,000	17,000
1" 1/4"	13,500	36,000	24,400	17,300	19,500

a. 1/4" manila--____________________

b. 1/4" polyethylene--____________________

c. 1 1/4" nylon--____________________

d. 3/4" polypropylene--____________________

e. 3/8" dacron--____________________

5. Calculate the mechanical advantage of using a 5 sheave block and tackle to lift a 500 lb load. Show your work.

6. List one use for each type of rope gear listed below.

a. Block and tackle--____________________

b. Sling--____________________

c. Hand line--____________________

d. Tag line--____________________

7. Calculate the safe working load of the following ropes, using a safety factor of 5.

   a. Manila rope with 450 lbs tensile strength

      Working load =

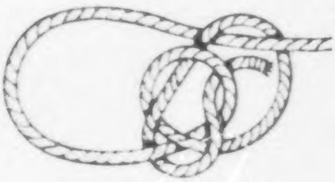
   b. Nylon rope with 3400 lbs tensile strength

      Working load =

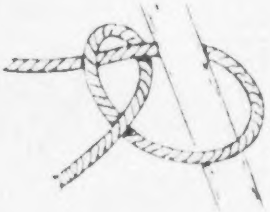
   c. Polyethylene rope with 2500 lbs tensile strength

      Working load =

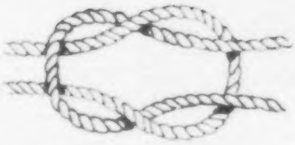
8. Identify the following knots and hitches.



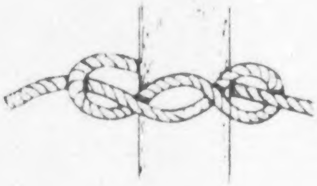
a. ______________________



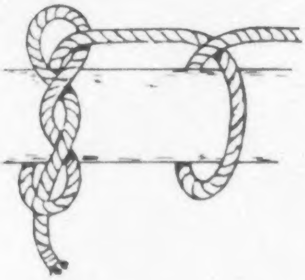
b. ______________________



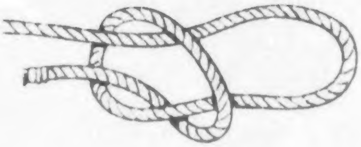
c. ______________________



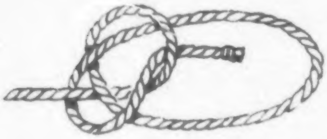
d. ______________________



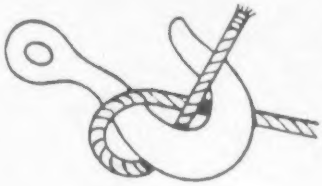
e. ____________________



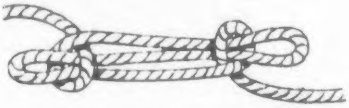
f. ____________________



g. ____________________



h. ____________________



i. ____________________

9. Match the types of knots and hitches on the right to the correct uses.

_____a. Raising poles

_____b. Securing to hook while under steady strain

_____c. Sending crossarm up pole

_____d. Sending tools and materials up pole

_____e. Tying for general purposes

_____f. Tying sling lines

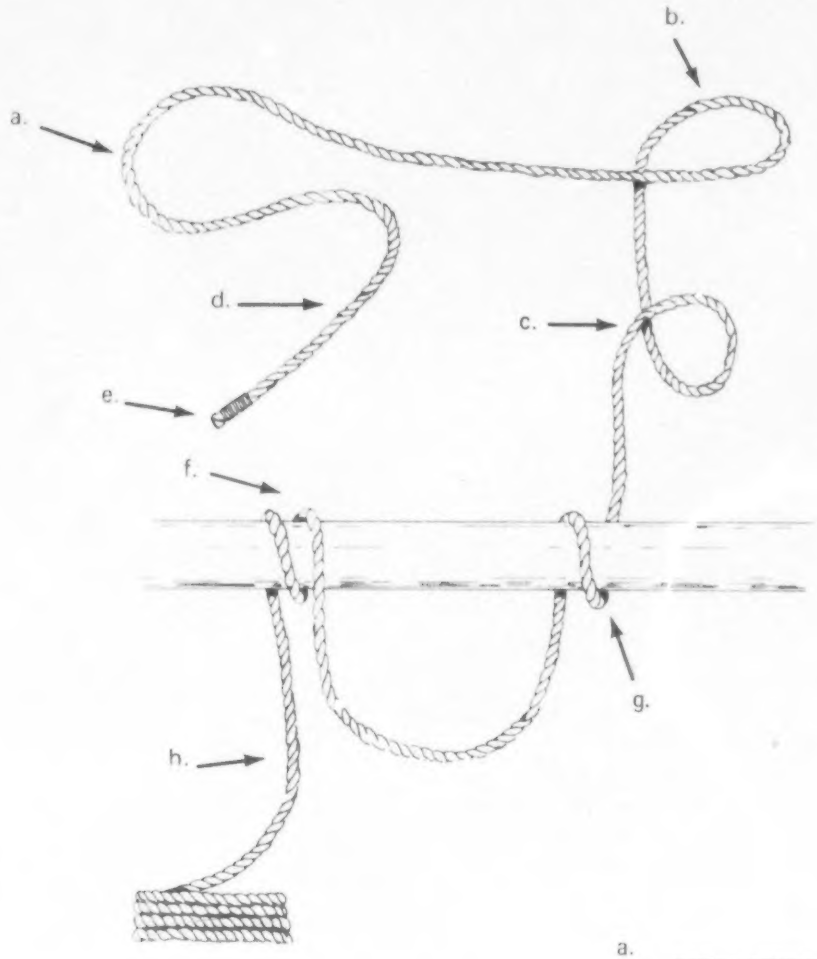
_____g. Tying to poles, pipe, or arms temporarily

_____h. Guying top of pole temporarily

_____i. Shortening rope

1. Square knot
2. Bowline
3. Slip knot
4. Timber hitch
5. Half hitch
6. Running bowline
7. Blackwall hitch
8. Sheepshank
9. Timber hitch with half hitch

10. Identify the following elements of knots, bends, and hitches by writing the correct names in the blanks provided.



a. ______________________

b. ______________________

c. ______________________

d. ______________________

e. ______________________

f. ______________________

g. ______________________

h. ______________________

11. List four conditions that damage rope.

a. ____________________

b. ____________________

c. ____________________

d. ____________________

ROPE AND RIGGING
UNIT IV

ANSWERS TO TEST

1. Match the terms on the right to the correct definitions.

3 a. Device to which the standing end of the rope in a block and tackle is secured

7 b. End of a block and tackle which is connected to the load to be moved

8 c. Greatest stress a rope can bear without breaking

10 d. Maximum load that should be applied to a rope

4 e. Rope to which pull is applied

5 f. To thread a rope around the sheaves in a set of blocks

9 g. Knot used to temporarily secure an object

2 h. Grooved wheel or pulley

1 i. Pulley or combination of pulleys operated with a rope

11 j. Short piece of rope; rope whose ends have been spliced together to form an endless rope; rope with an eye in each end

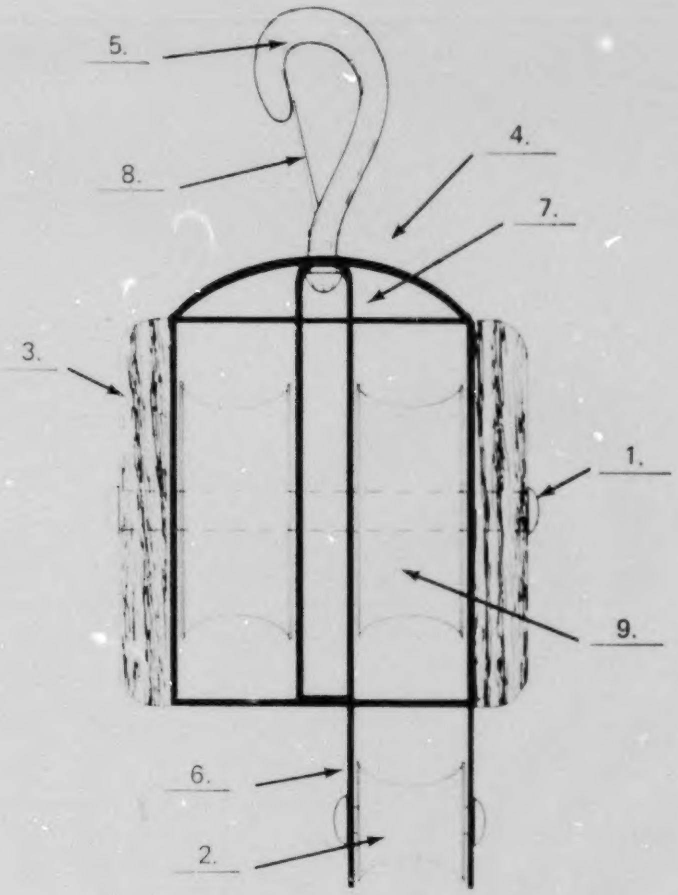
6 k. Use of a single line to apply pull more effectively

13 l. Rope used with single sheave block

12 m. Rope used to hold conductors away from pole

1. Block and tackle
2. Sheave
3. Becket
4. Fall line
5. Reeve
6. Fair lead
7. Traveling block
8. Tensile strength
9. Hitch
10. Working load
11. Sling
12. Tag line
13. Hand line

2. Identify the parts of the stationary block below by placing the correct numbers in the blanks.



1. Pin
2. Thimble
3. Shell
4. Outer strap
5. Hook
6. Becket
7. Inner strap
8. Safety catch
9. Sheaves

3. List four kinds of rope used in line work.

(NOTE: Any four of the following are acceptable.)

a. Manila

b. Nylon

c. Dacron

d. Polyethylene

e. Polypropylene

4. Determine the tensile strength of the following ropes by using the chart shown below.

Diameter	Manila	Nylon	Dacron	Poly-ethylene	Poly-propylene
3/16"	450	960	720	700	740
1/4"	600	1,500	1,150	1,200	1,250
5/16"	1,000	2,400	1,750	1,750	1,900
3/8"	1,350	3,400	2,450	2,500	2,700
7/16"	1,750	4,800	3,400	3,400	3,550
1/2"	2,650	6,200	4,400	4,100	4,500
9/16"	3,450	8,000	5,700	5,100	5,400
5/8"	4,400	10,000	7,300	6,000	6,600
3/4"	5,400	14,000	10,000	7,500	8,000
7/8"	7,700	19,000	13,600	9,900	10,750
1"	9,000	24,000	16,500	11,000	12,500
1" 1/8"	12,000	31,500	21,600	15,000	17,000
1" 1/4"	13,500	36,000	24,400	17,300	19,500

a. 1/4" manila--600

b. 1/4" polyethylene--1,200

c. 1 1/4" nylon--36,000

d. 3/4" polypropylene--8,000

e. 3/8" dacron--2,450

5. Calculate the mechanical advantage of using a 5 sheave block and tackle to lift a 500 lb load. Show your work.

5 sheaves = 5 to 1 theoretical mechanical advantage

500 ÷ 5 = 100 lbs theoretical pull needed

20% of 500 = 100 lbs
500 + 100 = 600 lbs
600 ÷ 5 = 120 lbs actual pull needed

500 ÷ 120 = 4.17
Actual mechanical advantage = 4 to 1

6. List one use for each type of rope gear listed below.

(NOTE: Any one from each group is acceptable.)

a. Block and tackle

   1) Raising and lowering small transformers

   2) Pulling wire

3) Lifting hot line tools

4) Lifting for general purposes

b. Sling

1) Lifting wire reels

2) Securing transformer to block and tackle

3) Securing conductor to pole

4) Lashing for general purposes

c. Hand line

1) Sending tools and small equipment to line mechanic on pole

2) Lowering tools and equipment from pole

3) Lowering line mechanic from pole in rescue situation

d. Tag line--Tying to insulating stick to hold conductor away from pole

7. Calculate the safe working load of the following ropes, using a safety factor of 5.

a. Manila rope with 450 lbs tensile strength

Working load = 90 lbs

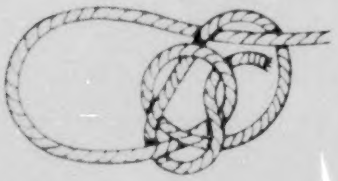
b. Nylon rope with 3400 lbs tensile strength

Working load = 680 lbs

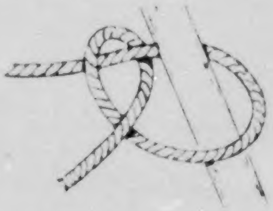
c. Polyethylene rope with 2500 lbs tensile strength

Working load = 500 lbs

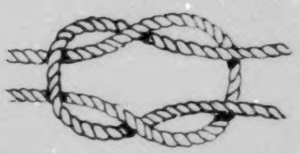
8. Identify the following knots and hitches.



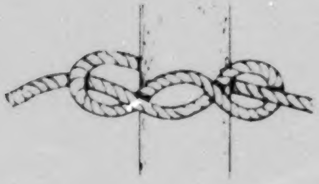
a. Running bowline



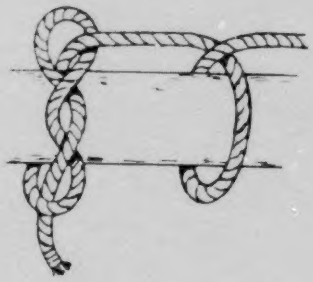
b. Half hitch



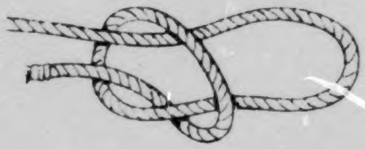
c. Square knot



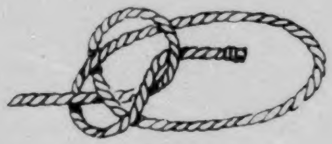
d. Timber hitch



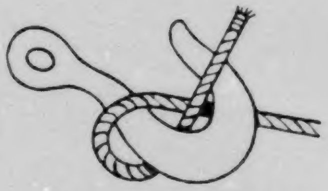
e. Timber hitch with half hitch



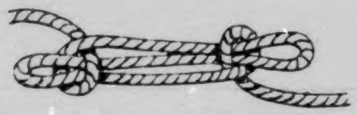
f. Slip knot



g. Bowline



h. Blackwall hitch



i. Sheepshank

9. Match the types of knots and hitches on the right to the correct uses.

4 a. Raising poles

7 b. Securing to hook while under steady strain

9 c. Sending crossarm up pole

3 d. Sending tools and materials up pole

2 e. Tying for general purposes

1 f. Tying sling lines

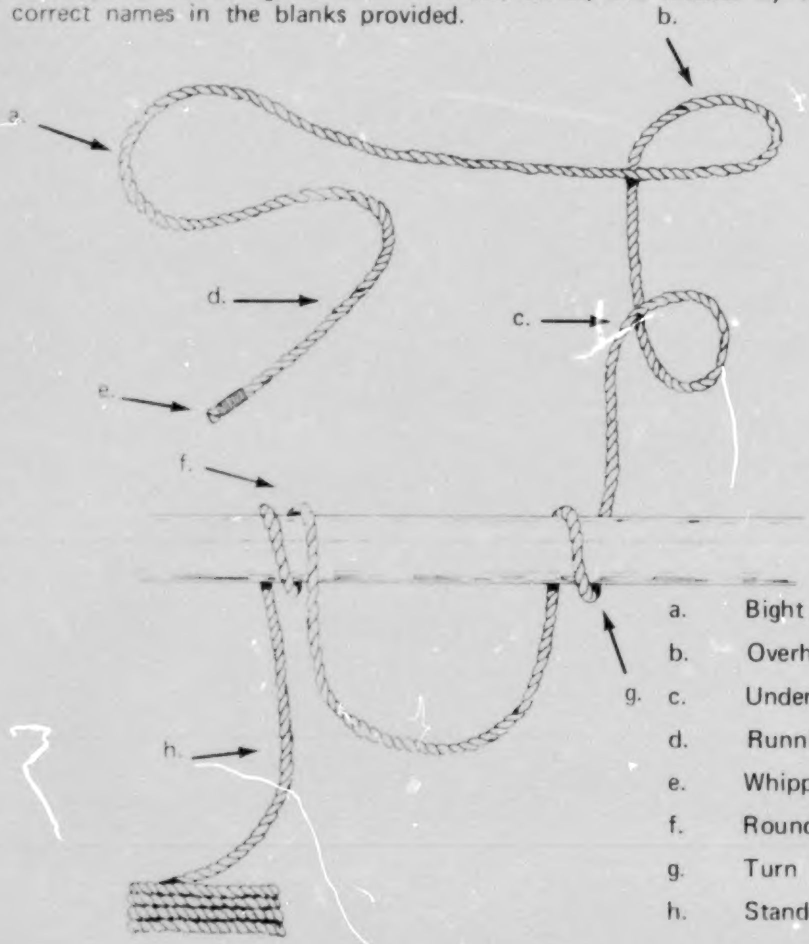
5 g. Tying to poles, pipe, or arms temporarily

6 h. Guying top of pole temporarily

8 i. Shortening rope

1. Square knot
2. Bowline
3. Slip knot
4. Timber hitch
5. Half hitch
6. Running bowline
7. Blackwall hitch
8. Sheepshank
9. Timber hitch with half hitch

10. Identify the following elements of knots, bends, and hitches by writing the correct names in the blanks provided.



a. Bight
b. Overhand loop
c. Underhand loop
d. Running end
e. Whipping
f. Round turn
g. Turn
h. Standing part

11. List four conditions that damage rope.

(NOTE: Any four of the following are acceptable.)

a. Improper knots or hitches

b. Vehicles or foot traffic over rope

c. Incorrect block and sheave size

d. Overloading or sudden jerks

e. Exposure to acid, fumes, or oil

f. Dragging rope over sharp objects

g. Permitting rope to freeze when wet

h. Exposure to extreme heat

OVERHEAD CONSTRUCTION
UNIT V

UNIT OBJECTIVE

After completion of this unit, the student should be able to identify hand tools, construction equipment, and various connectors and match them to their specific uses. The student should be able to select from a chart the proper depth to set a pole and state procedures for installing a pole key and ground rod. This knowledge will be evidenced by scoring 85 percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms associated with overhead construction to the correct definitions.
2. Match materials commonly used in overhead construction to their specific uses.
3. Identify hand tools commonly used in overhead construction.
4. Match hand tools to their specific uses.
5. Identify overhead construction tools.
6. Match overhead construction tools to their specific uses.
7. List elements of overhead construction.
8. Identify equipment used in overhead construction.
9. Match equipment commonly used in overhead construction to their specific uses.
10. Select from a chart the correct depth to set poles of varying lengths.
11. List methods used to properly sag conductors.
12. Identify various types of connectors used in overhead construction.
13. Match types of construction to the correct descriptions.
14. List steps to properly install a pole key.
15. State correct procedure for installing a ground rod.
16. Arrange in order the steps to follow when framing a pole.
17. Identify various structures used in transmission line construction.

OVERHEAD CONSTRUCTION
UNIT V

SUGGESTED ACTIVITIES

I. Suggested activities for instructor:

  A. Provide student with objective sheet.

  B. Provide student with information sheet.

  C. Make transparencies.

  D. Discuss unit and specific objectives.

  E. Discuss information sheet.

  F. Give test.

II. Unit references:

  A. Rural Electrification Administration. *Specifications and Drawings for 7.2/12.5 Kv. Line Construction.* REA Form 804. Washington, D.C.: U.S. Department of Agriculture, August 1962.

  B. Rural Electrification Administration. *Specifications and Drawings for 14.4/24.9 Kv. Line Construction.* REA Form 803. rev. Washington, D.C.: U.S. Department of Agriculture, September 1969.

  C. Kurtz, Edwin B., and Shoemaker, Thomas M. *The Lineman's and Cableman's Handbook.* 5th ed. New York: McGraw-Hill Book Co., 1976.

  D. Rural Electrification Administration. *Electric Transmission Construction Contract.* REA Form 831. Washington, D.C.: U.S. Department of Agriculture, February 1973.

OVERHEAD CONSTRUCTION
UNIT V

INFORMATION SHEET

I. Terms and definitions

A. Overhead stub--Pole used to elevate guy wire over roadways or obstructions (Transparency 1)

B. Guy strand--Strong steel wire used to hold against conductor strain between pole and anchor

C. Dead end--Place in the line where the conductor is connected to an attachment and may or may not continue to other poles (Transparency 1)

D. Pole brand--Marking found on pole which gives the kind of wood, the date pole was treated, the manufacturer, and the length and class of pole (Transparency 2)

E. Pole gain--Area at the top of a pole which is planed and drilled for crossarm or hardware attachment (Transparency 2)

F. Stub pole--Short length of pole strapped and bolted to an existing pole for support (Transparency 3)

G. Framing--Removing bark, trimming, gaining, boring holes, and attaching grounds and hardware

H. Canting--Aligning the holes in a pole with the conductor or at an angle to the conductor

I. Rake--To lean a pole against conductor strain (Transparency 4)

J. Piking--Using a long, round pole with a pointed metal spike on one end to plumb or hold a pole straight while setting

K. Pole key--Section of a pole or a treated plank used to brace a pole (Transparency 4)

L. Sag--Distance between a straight line and where the conductor is recommended to be hung (Transparency 5)

M. Dolly--Pulley mounted on a crossarm or pole to string conductor through when stringing long runs of conductor

N. Lagging--Soft wood planks nailed or strapped across conductor reels to protect the conductor (Transparency 6)

O. Distribution line--Line which carries 2,300 to 34,500 volts of power throughout urban and rural areas

P. Transmission line--Line which carries power over great distances between generation plant and substations

INFORMATION SHEET

II. Materials used in overhead construction (Transparencies 7 through 11)

(NOTE: A partial list of commonly used materials is given below. It does not contain all materials used in overhead construction.)

A. 5/8" machine bolt--Attaches hardware and equipment to poles

B. 3/4" machine bolt--Used in heavier distribution and transmission line construction and for pole stubbing

C. 1/2" machine bolt--Used to bolt heavy-duty crossarm braces to crossarm

D. 3/8" carriage bolt--Used to bolt standard crossarm braces to crossarm

E. Double arming bolt--Used to bolt crossarms together when two or more crossarms are used

F. Eye bolt--Used where a dead end in the primary or neutral is constructed

G. Thimble eye bolt--Used with guy wire on overhead guys

H. Eye nut--Used on the back side of an eye bolt when a double dead end is constructed

I. Upset bolt--Used in the neutral position on primary structure for attaching the neutral conductor

J. Double upset bolt--Used to hold conductor an extended distance from pole

K. Dead-end shoe--Used to secure conductor at a dead end

L. Clevis--Used to hold a spool insulator

M. Spool insulator--Used with both large and small clevises for service dead ends and neutral dead ends and on upset bolts

N. Wire holder--Used for screwing into wood or clamping around pipe

O. Square washer--Used with all bolts when nut does not tighten against other hardware

P. Anchor shackle--Used to connect eye bolts or eye bolt and eye nut together

Q. Suspension insulator (bell)--Used to dead end or suspend conductor on angle poles or is hung below crossarm to suspend conductor on higher voltage systems

R. Anchor--Used with a rod for attaching guy wire to hold against conductor strain

INFORMATION SHEET

   S. Insulator pin--Used on a crossarm to attach an insulator
   T. Connector-Connects conductors together which are not under strain
   U. Locknut--Used on all bolts
   V. Pole top pin--Bolts to top of pole to hold insulator
   W. Butt plate--Fastens to the bottom of a pole for a ground

III. Hand tools used in overhead construction (Transparency 12)

   A. Line technician's pliers
   B. Ratchet wrench
   C. Screwdriver
   D. Adjustable wrench
   E. Skinning knife
   F. Line technician's hammer
   G. Folding wood rule

IV. Uses of hand tools

   A. Line technician's pliers-Cuts and serves soft wire
   B. Screwdriver--Drives and removes screws
   C. Line technician's hammer--Drives lag screws and steeples
   D. Ratchet wrench--Loosens and tightens connectors, bolts, and nuts
   E. Adjustable wrench-Tightens nuts and connectors
   F. Skinning knife--Removes insulation
   G. Folding wood rule-Measures spacing for material

V. Overhead construction tools (Transparencies 13 and 14)

   A. Pulling grips
      1. Wire grip
      2. Guy grip

INFORMATION SHEET

B. Hoists

    1. Chain hoist
    2. Cable hoist
    3. Insulated strap hoist

C. Cant hook

D. Pole carrying hook

E. Pole jack

F. Anchor auger

G. Digging shovel

H. Digging spoon

I. Tamp

J. Pole framing gin

K. Transformer gin

L. Bolt cutters

M. Load binder and chain

N. Compression tool

VI. Uses of overhead construction tools

A. Pulling grip--Attaches to conducter and is used with hoist or block and tackle to pull conductor or guy wire

B. Hoist--Pulls tension on conductor or guy wire

C. Cant hook--Turns poles

D. Pole carrying hook--Carries poles

E. Pole jack--Pulls or straightens poles

F. Anchor auger--Digs anchor holes

G. Digging shovel--Digs pole holes

H. Digging spoon--Removes loose dirt from pole holes

I. Tamp--Packs soil around poles or on anchors

INFORMATION SHEET

J. Pole framing gin--Elevates and holds pole while framing material is being installed

K. Transformer gin--Attaches to pole to hold block and tackle for lowering or raising transformer

L. Bolt cutters--Cut guy wire and heavy conductor

M. Load binder and chain--Binds poles to truck or pole trailer

N. Compression tool--Crimps sleeves and connectors

VII. Elements of overhead construction

A. Pole loading, hauling, framing, setting, and removing

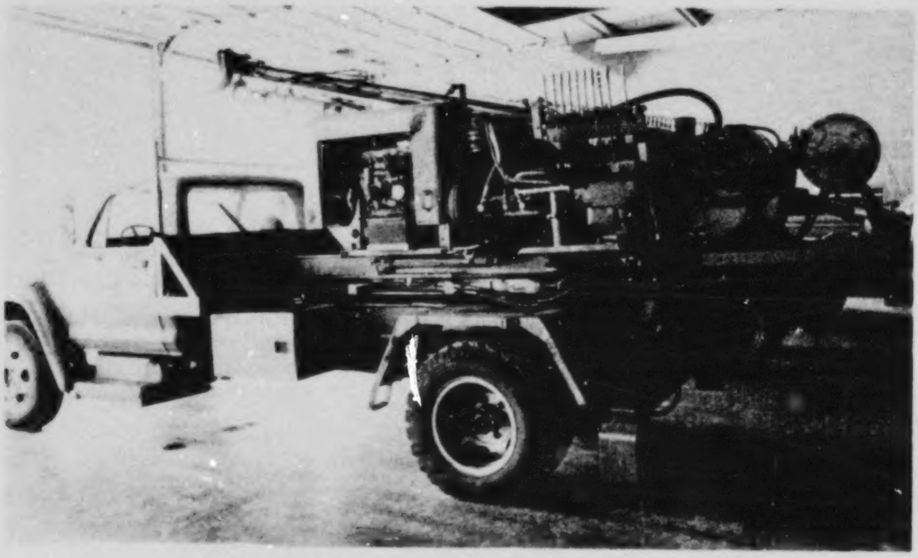
B. Anchor setting

C. Guy make-up and pulling

D. Conductor stringing, laying up, sagging, and tying in

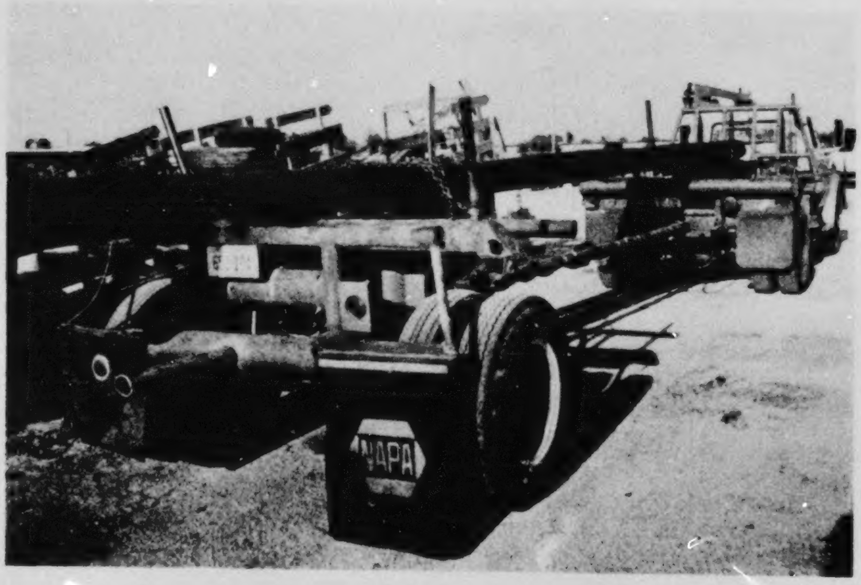
VIII. Equipment used in overhead construction

A. Hole digger derrick

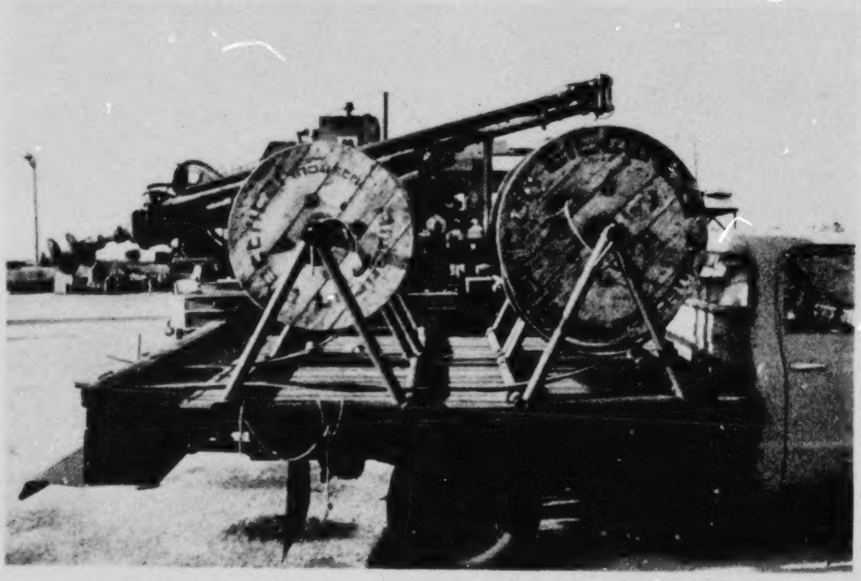


INFORMATION SHEET

B. Pole truck and trailer

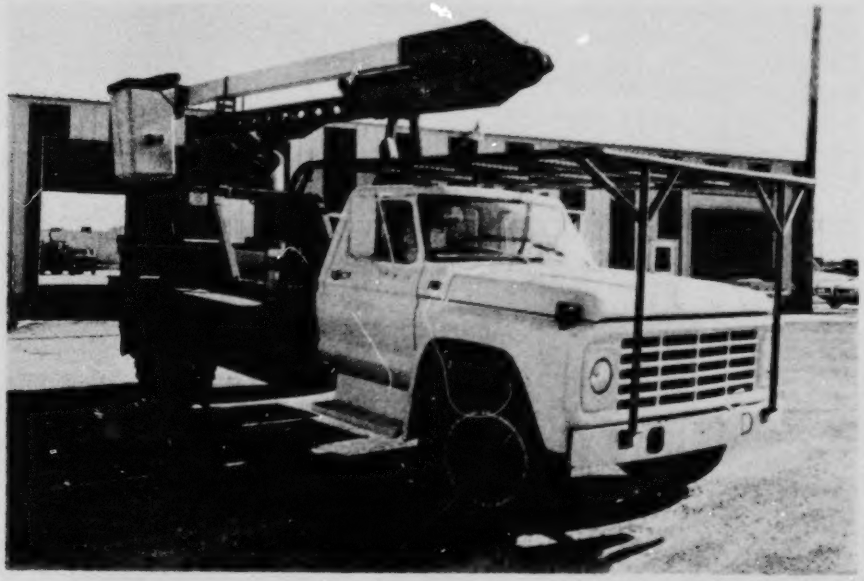


C. Conductor-stringing truck



INFORMATION SHEET

D. Basket truck



IX. Uses of overhead construction equipment

A. Hole digger derrick--Digs pole and anchor holes; sets and pulls poles

B. Pole truck and trailer--Carry poles and materials to job site

C. Conductor-stringing truck and trailer--Carry reels of primary and service conductor to job site

D. Basket truck--Assists line technician in reaching and working near energized conductors

INFORMATION SHEET

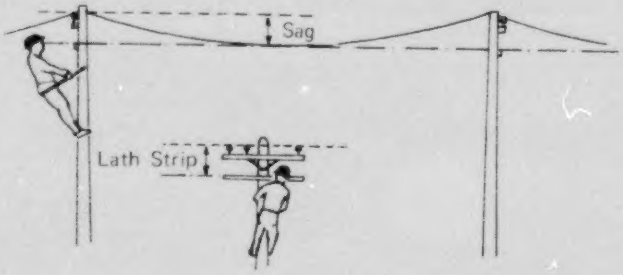
X. Minimum depth to set poles

Length of Pole (feet)	Setting in Soil (feet)	Setting in All Solid Rock (feet)
20	4.0	3.0
25	5.0	3.5
30	5.5	3.5
35	6.0	4.0
40	6.0	4.0
45	6.5	4.5
50	7.0	4.5
55	7.5	5.0
60	8.0	5.0
65	8.5	
70	9.0	
75	9.5	
80	10.0	
85	10.5	
90	11.0	
95	11.0	
100	11.0	

Pole setting depth for lengths of 65 feet or more may be decreased from soil setting depth by two feet when pole is set in solid rock

XI. Methods used to sag conductor

A. Sighting



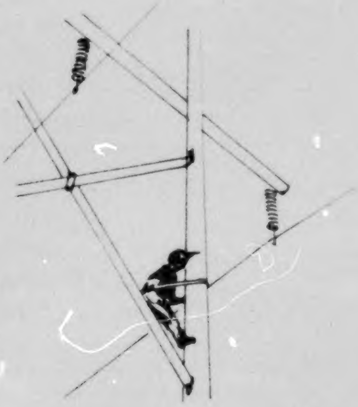
B. Return wave (Transparency 15)

(NOTE: The return wave method of checking sag requires a sagging table or chart which indicates sag according to the time required for an induced wave to travel from one support to another and return three, five, ten, or fifteen times. Sag cannot be checked by this method if there is a sleeve in the span.)

INFORMATION SHEET

C. Transit

(NOTE: When span lengths are very long, a person cannot see the conductor in mid-span and the next support. A transit is secured and leveled on a support and enables the person sagging the conductor to see the greater span lengths.)

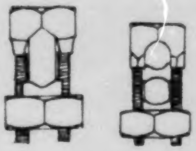


D. Dynamometer (Transparency 16)

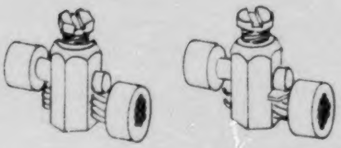
(NOTE: A dynamometer is used to measure the tension of a conductor rather than the amount of sag.)

XII. Connectors used in overhead construction

A. Split bolt

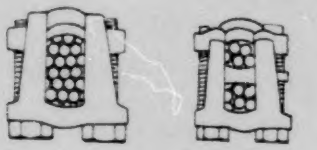


B. Service entrance

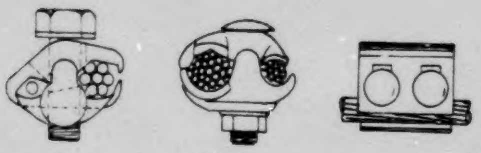


INFORMATION SHEET

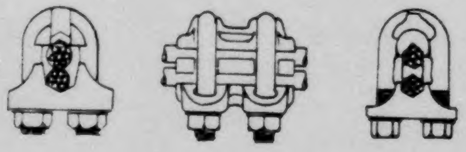
C. Two bolt



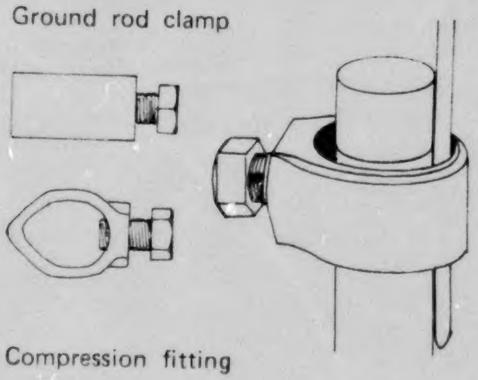
D. Center bolt



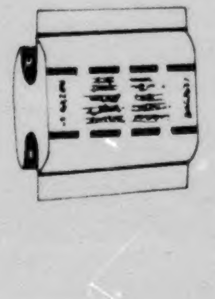
E. U-bolt clamp



F. Ground rod clamp

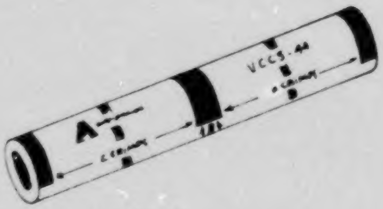


G. Compression fitting



INFORMATION SHEET

H. Compression sleeve



(NOTE: The manufacturer's recommendations should be followed for conductor and sleeve size. Connectors A, B, C, and E are shown with and without a spacer between the conductors. The connectors with the spacer are used when connecting copper and aluminum.)

XIII. Types of construction (Transparency 17)

(NOTE: The following grades of construction with a "V" prefix are 14,400/24,970-volt construction. Any construction grade without the "V" designates 7200/12,470-volt construction.)

A. VA--One primary conductor with one neutral conductor

(NOTE: Type A construction is usually referred to as *single-phase construction*.)

B. VB--Two primary conductors with one neutral conductor

(NOTE: Type B construction is sometimes referred to as *V-phase construction*.)

C. VC--Three primary conductors with one neutral conductor

(NOTE: Type C construction is usually referred to as *three-phase construction*.)

D. VDC--Six primary conductors with one neutral conductor

(NOTE: Type DC construction is usually referred to as *double circuit construction*.)

XIV. Steps to install a pole key

A. Dig trench the required length at a right angle to conductor strain

INFORMATION SHEET

B. Insert pole key in trench so that top of key is 12" below ground

(NOTE: The pole key should fit against pole and trench so that key is next to undisturbed soil.)

XV. Procedure for installing ground rod

A. Dig trench 14" deep and 30" long parallel with overhead conductors

B. Drive ground rod into undisturbed soil 2' from pole

(NOTE: The top of the ground rod must be a minimum of 12" below ground.)

XVI. Steps in pole framing

A. Roll pole onto framing gin with cant hook

B. String and steeple pole ground to pole

C. Place steeples 6" apart from ground level to 8' above ground and 8' from top of pole

D. Place steeples 2' apart on remainder of pole

E. Install required hardware with square washers and locknuts on all bolts

F. Install crossarm, if required

G. Check pole ground for clearance between pole ground and hardware

(NOTE: The pole ground should clear all hardware at least 2" to prevent radio and television interference from arcing between the pole ground and hardware.)

XVII. Transmission line structures (Transparencies 18-21)

A. 69 kV single pole double circuit

B. 69 kV single pole single circuit

C. 69 kV two pole single circuit

D. 115 kV H-frame

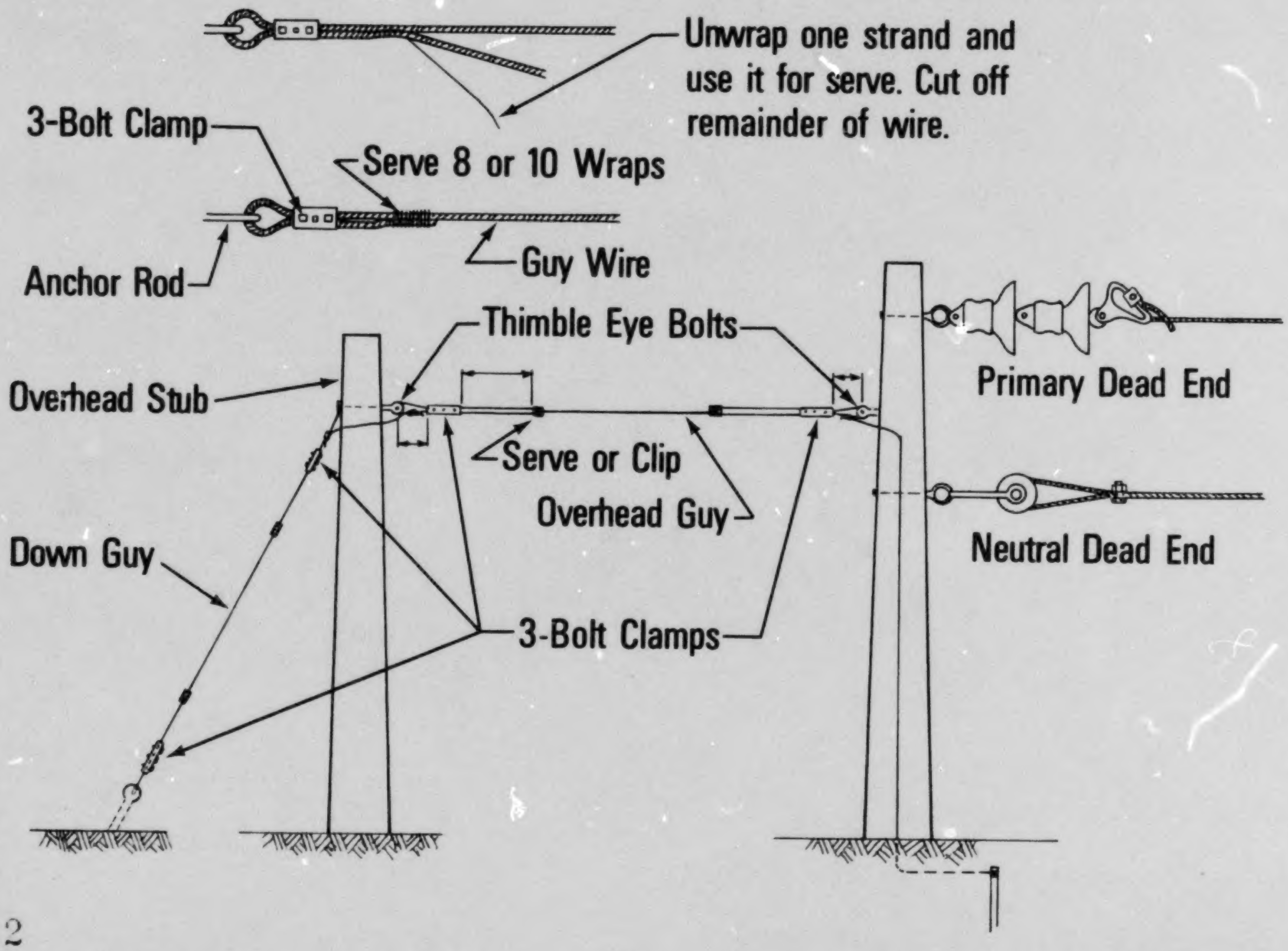
E. 230 kV H-frame

F. 69 kV-230 kV steel pole single and double circuit

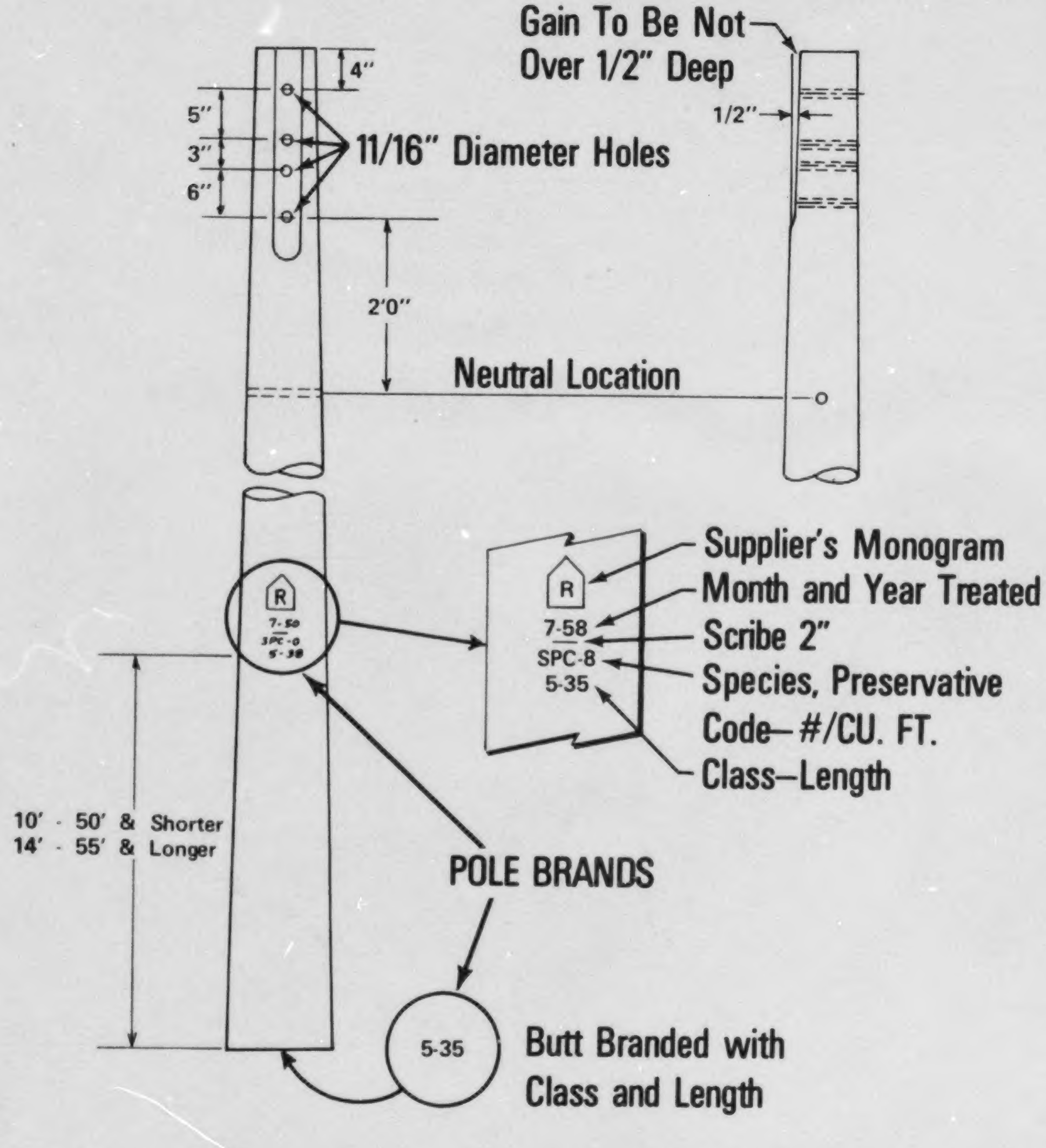
G. 115 kV steel tower single circuit

H. 345 kV steel tower double circuit

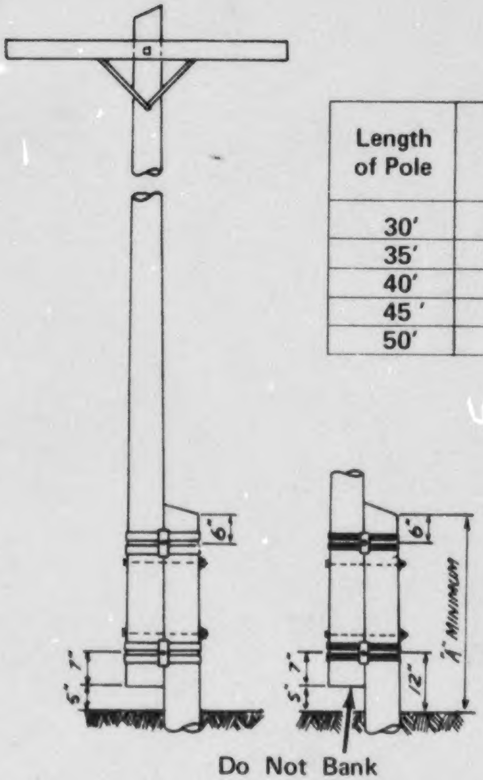
Overhead Stub with Dead Ends and Guys



Pole Brand, Pole Gain, and Drilling Specifications

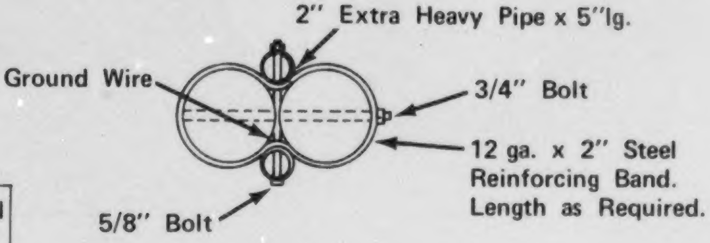


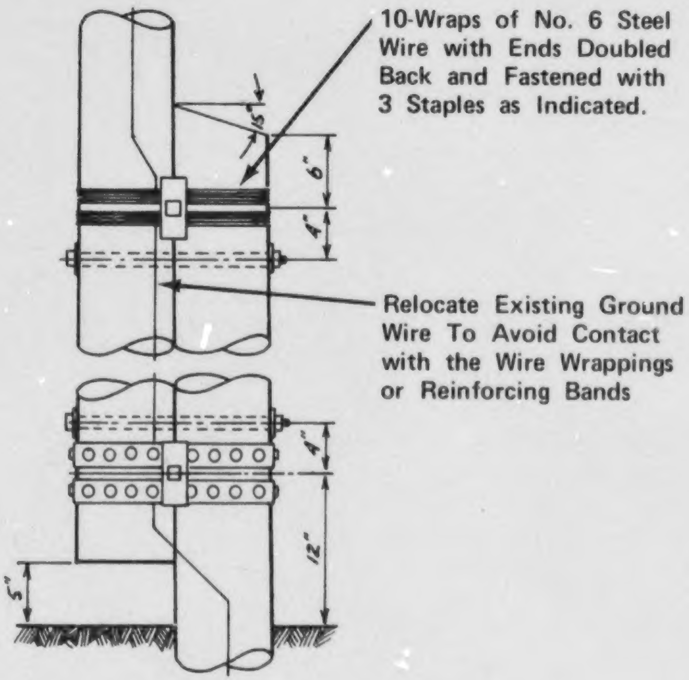
Stub Pole



TYPE A TYPE B

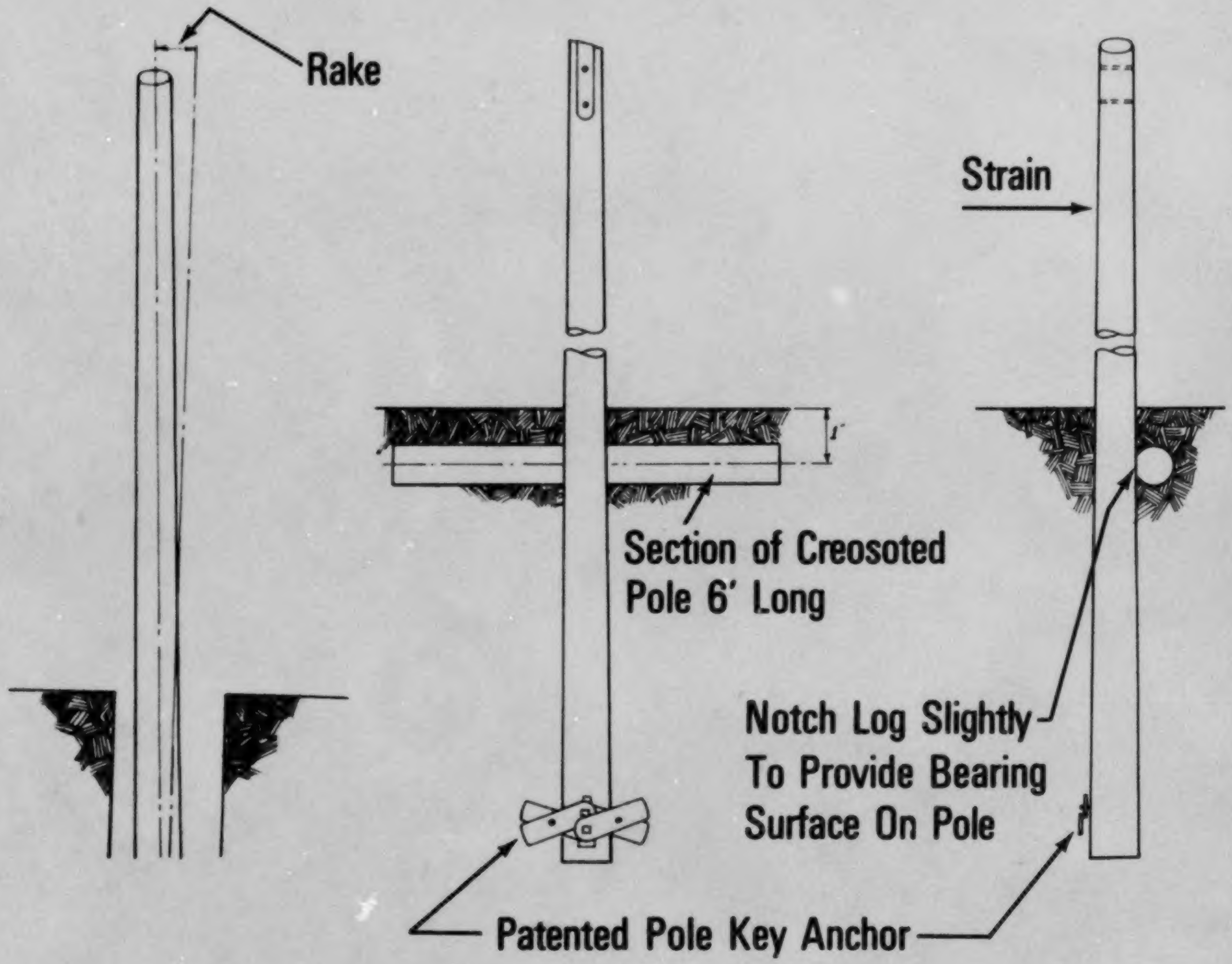
Length of Pole	A	Min. Total Length of Stub
30'	5'-0"	10'-6"
35'	5'-0"	11'-0"
40'	5'-6 "	11'-6"
45 '	6'-0"	12'-6"
50'	6'-0"	13'-0"


2" Extra Heavy Pipe x 5"lg.
Ground Wire
3/4" Bolt
12 ga. x 2" Steel Reinforcing Band. Length as Required.
5/8" Bolt

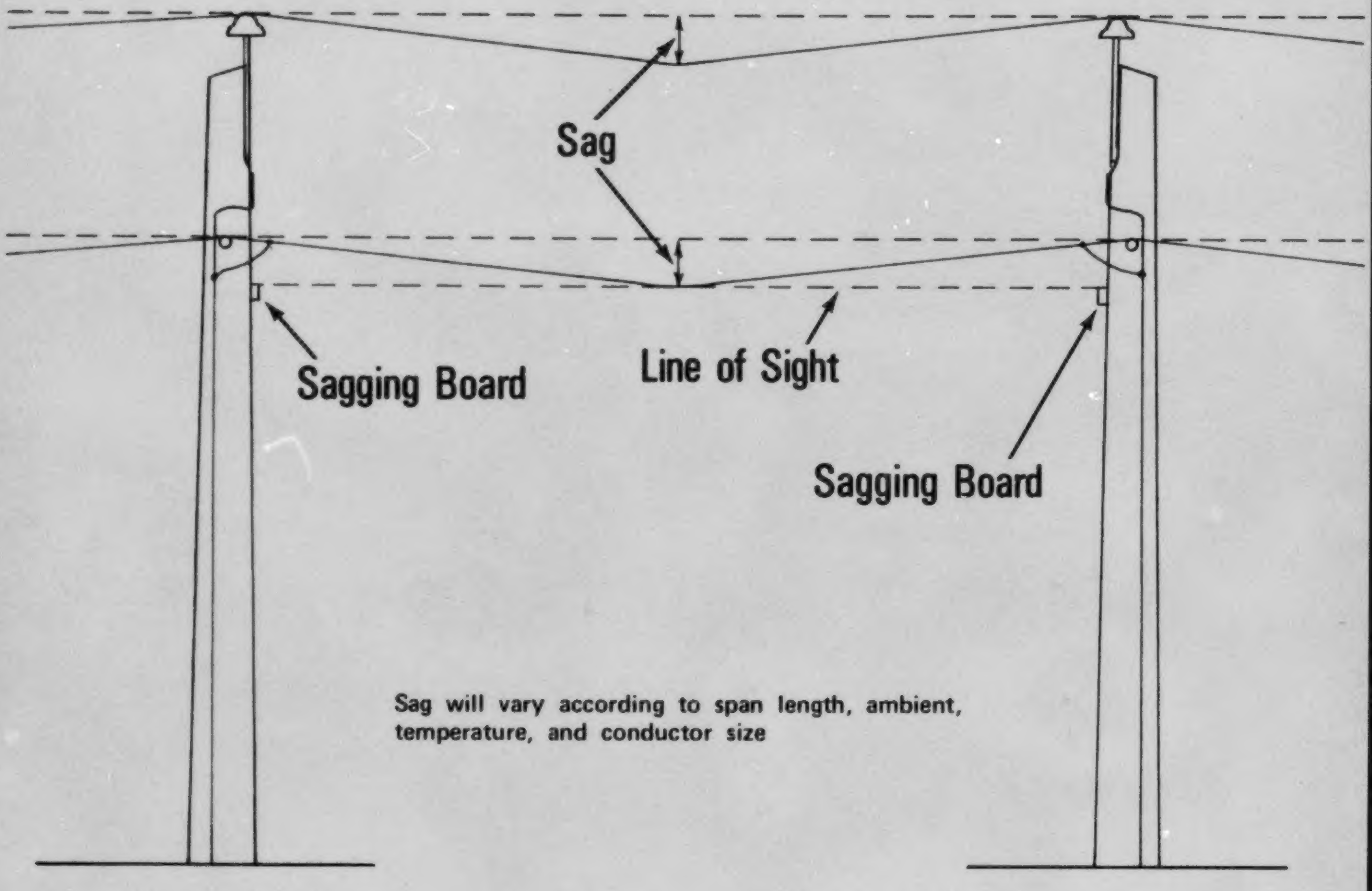

10-Wraps of No. 6 Steel Wire with Ends Doubled Back and Fastened with 3 Staples as Indicated.
15°
6"
4"
Relocate Existing Ground Wire To Avoid Contact with the Wire Wrappings or Reinforcing Bands
4"
12"
5'

Use either wire wrapping or reinforcing band for stubbing material as required. Position of stub at side of pole (At right angle to direction of line and outside of angle.)

Pole Rake and Pole Keys


Rake
Strain
1'
Section of Creosoted Pole 6' Long
Notch Log Slightly To Provide Bearing Surface On Pole
Patented Pole Key Anchor

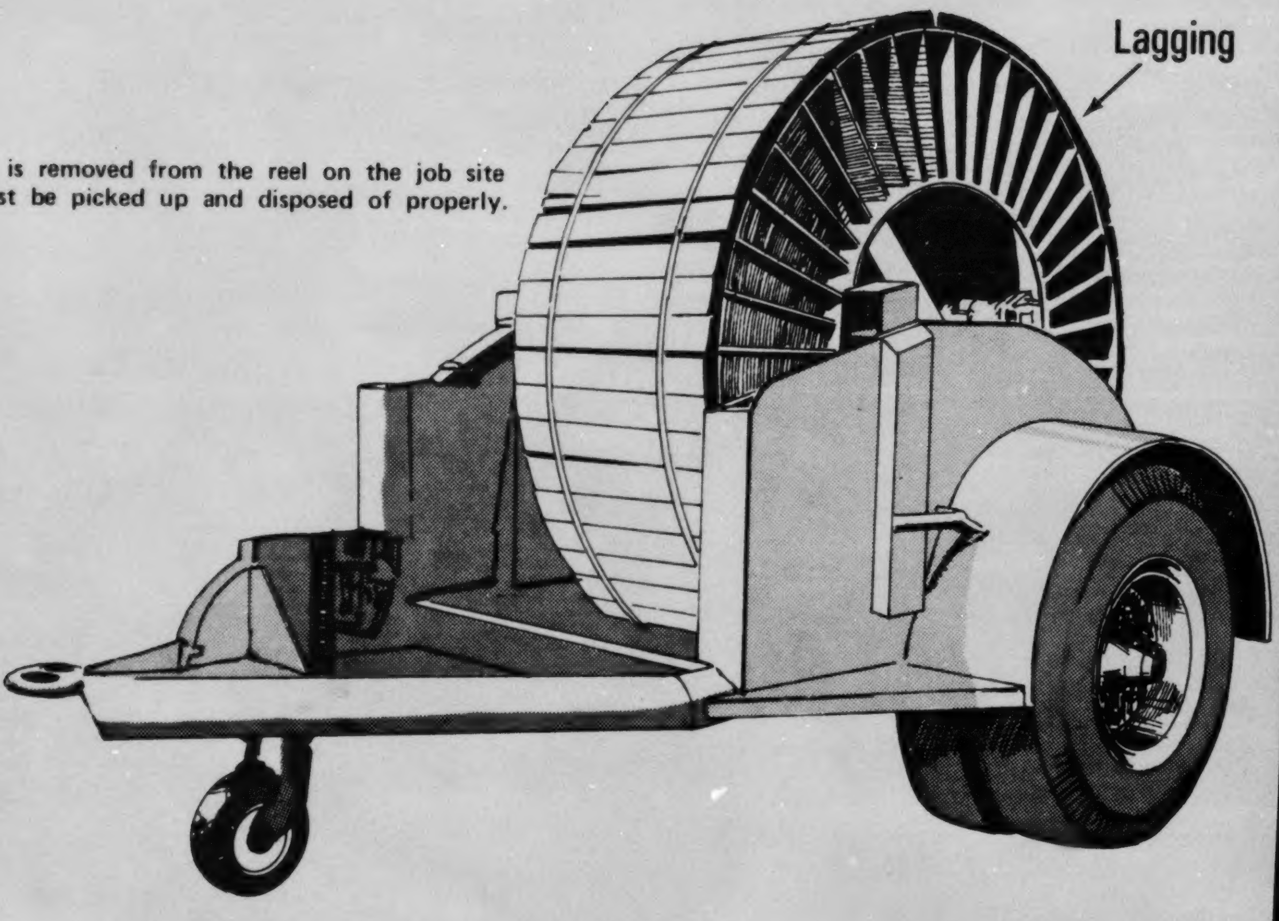
Sag



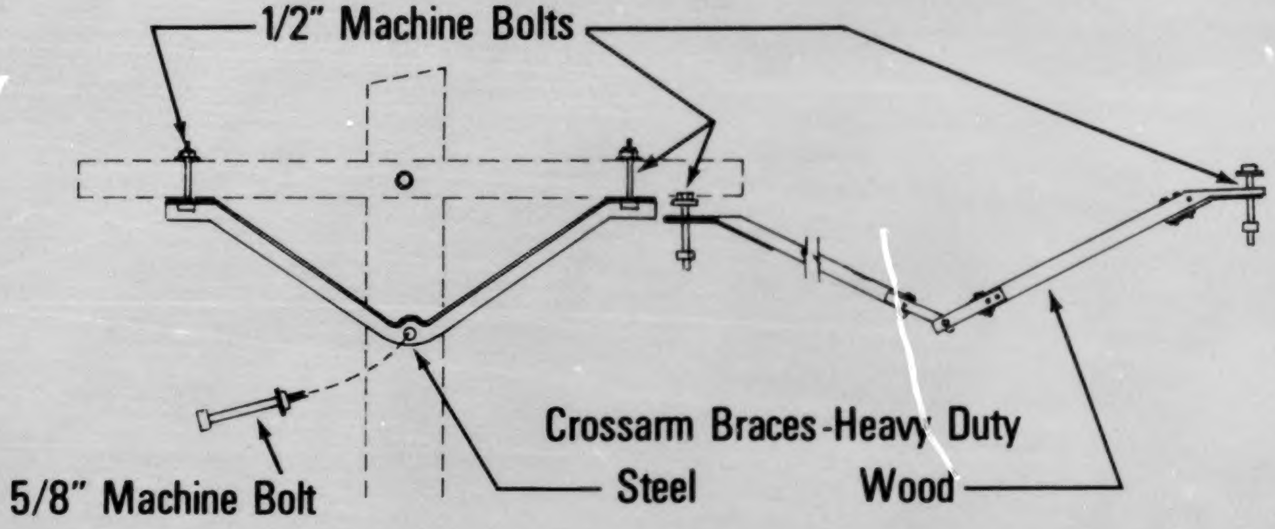
Sag will vary according to span length, ambient, temperature, and conductor size

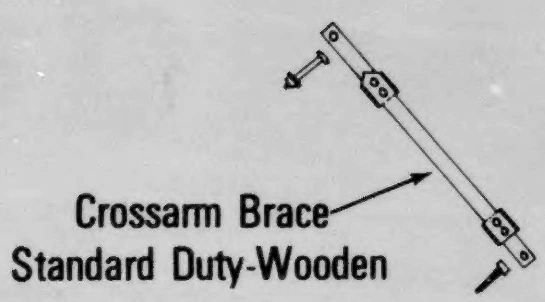
Lagging

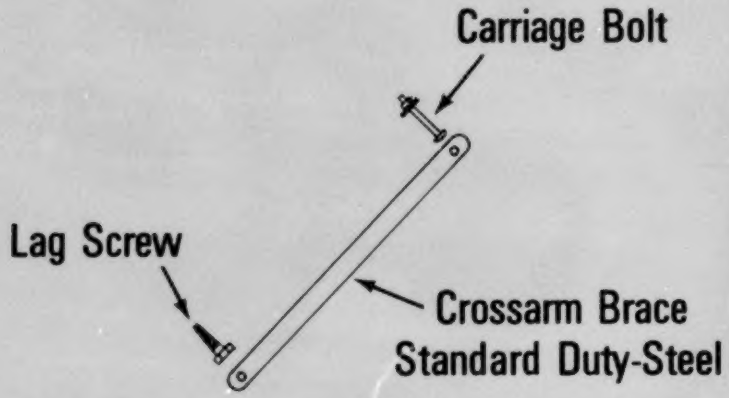
Lagging is removed from the reel on the job site and must be picked up and disposed of properly.



Materials Used In Overhead Construction

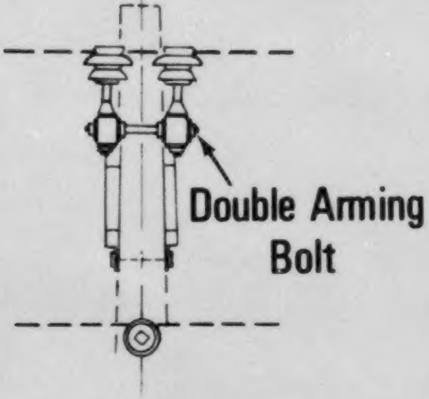


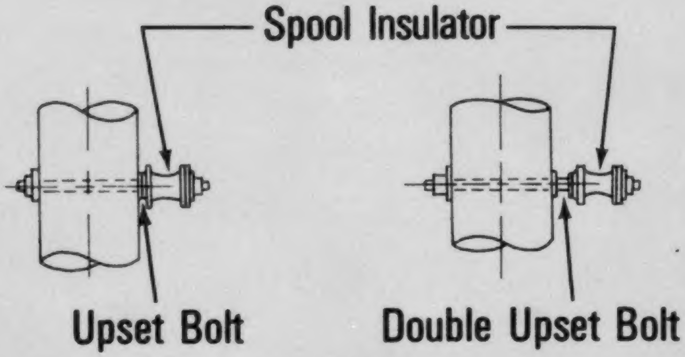


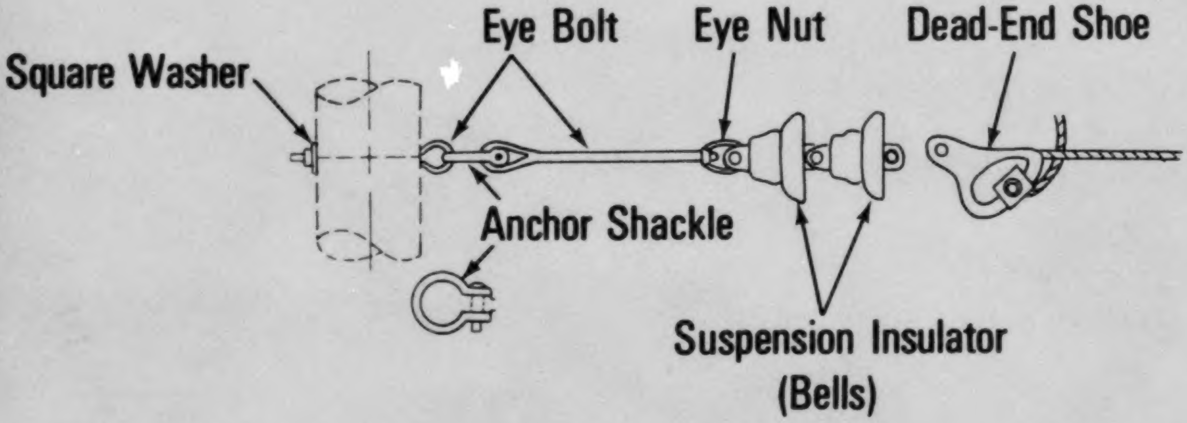


Materials Used In Overhead Construction

(Continued)

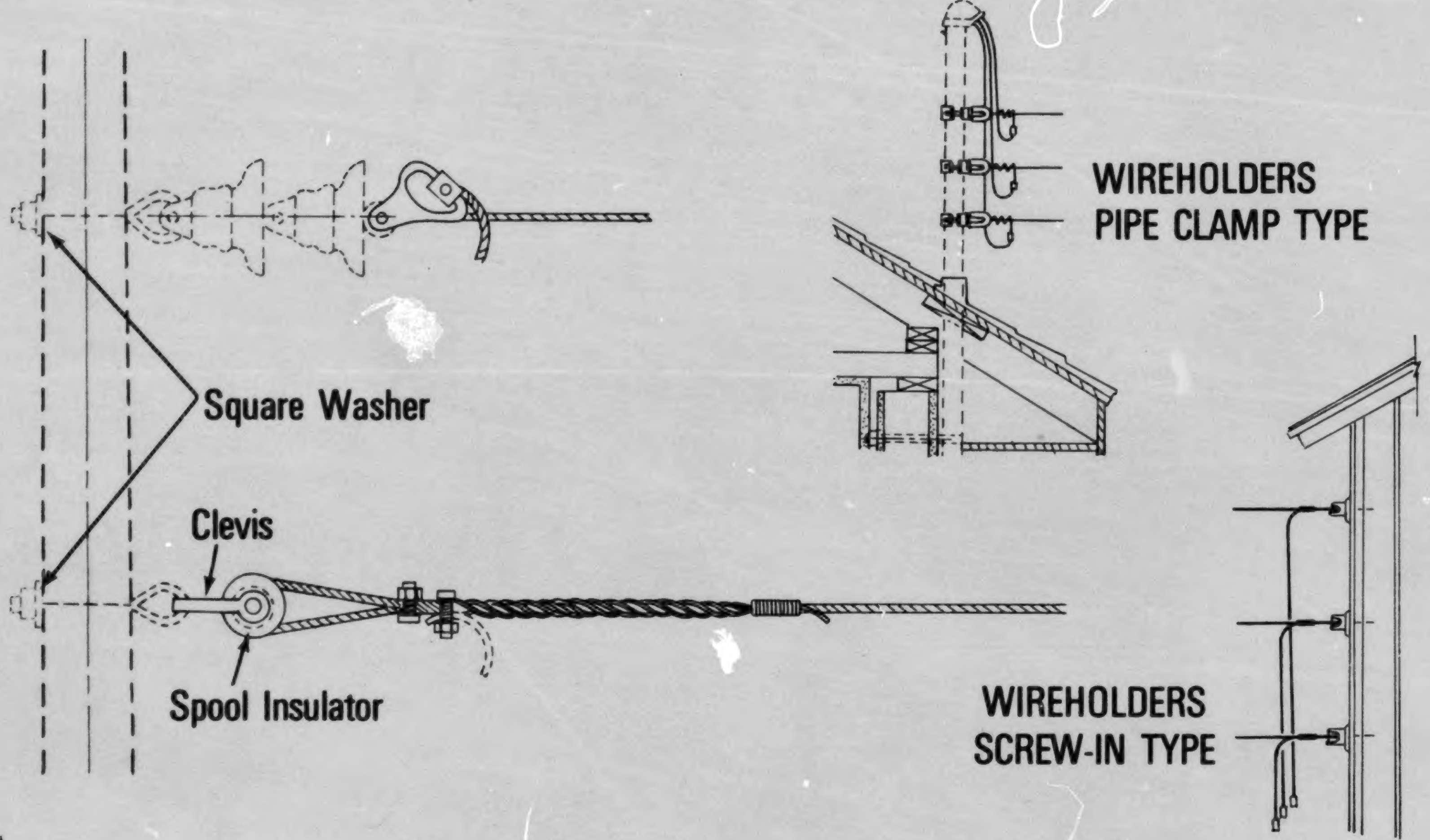






Materials Used In Overhead Construction

(Continued)

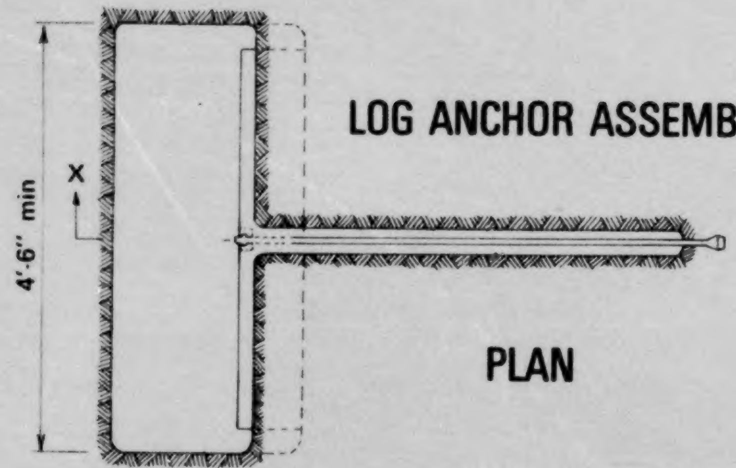


TM 9

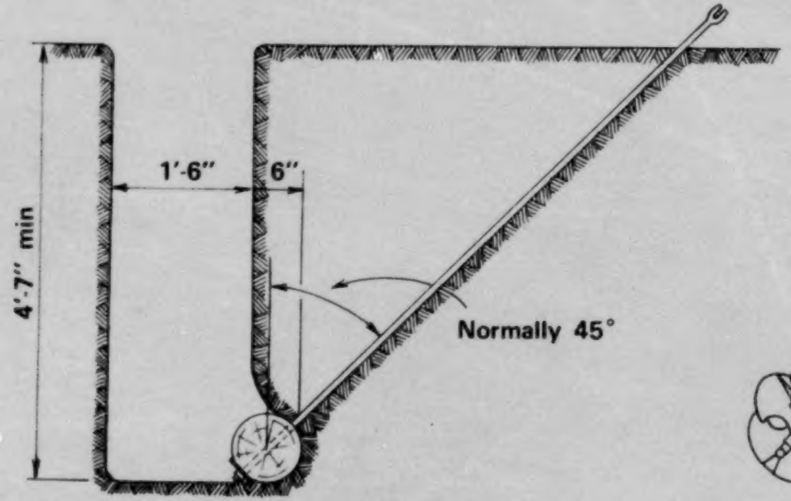
PLT - 219-B

Anchor Assembly

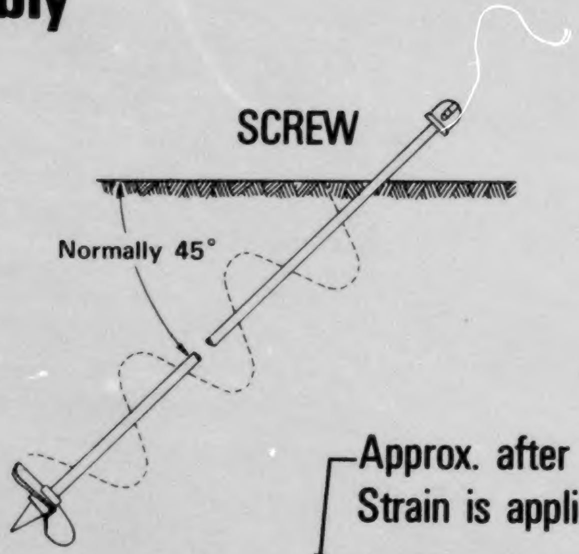
LOG ANCHOR ASSEMBLY

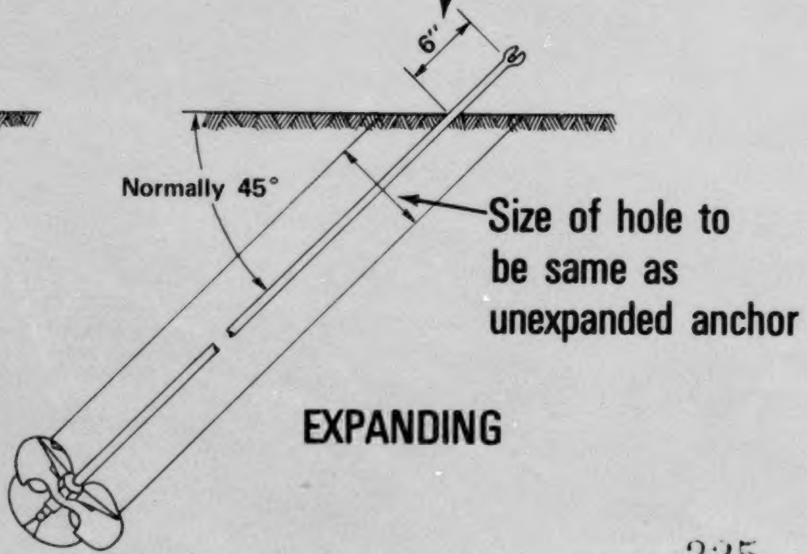


PLAN



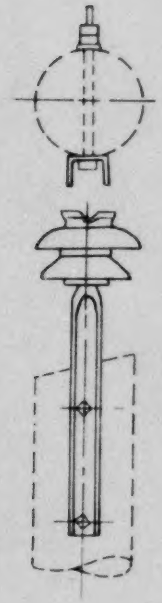
SCREW

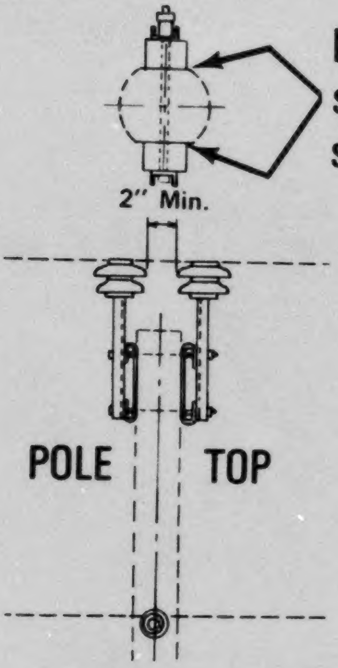



Approx. after Strain is applied
6"
Normally 45°
Size of hole to be same as unexpanded anchor

EXPANDING

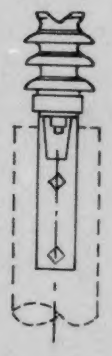
Insulator Pins



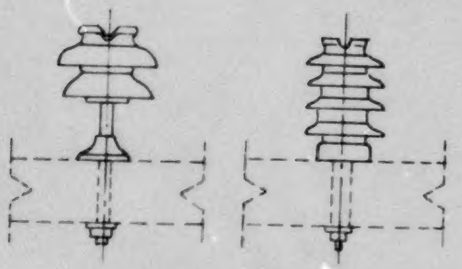


Pole to be gained on both sides to provide flat surfaces for the brackets.

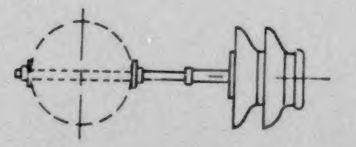
POLE TOP



Pole-Top Pins Are Referred To As Ridge Pins



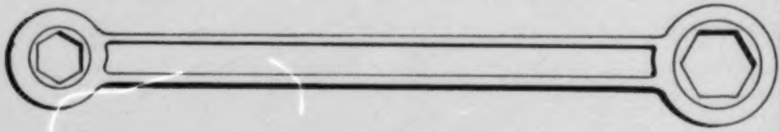
CROSSARM



STAND OFF

Hand Tools

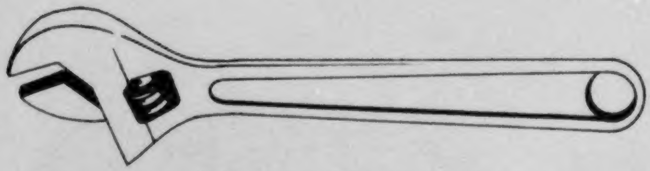
Screwdriver


Ratchet Wrench

Line Technician's Pliers

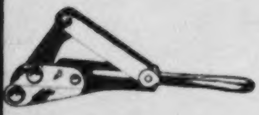
Line Technician's Hammer

Skinning Knife

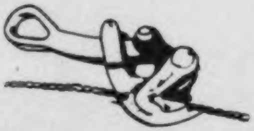

Adjustable Wrench

Overhead Construction Tools

Pulling Grips

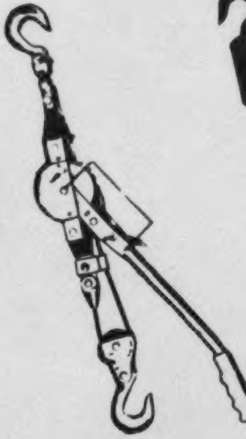


Wire Grip

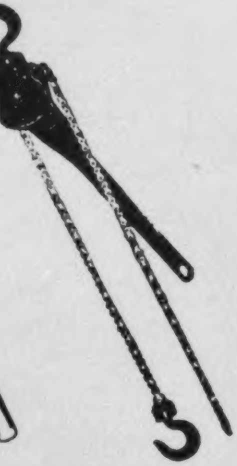


Guy Grip

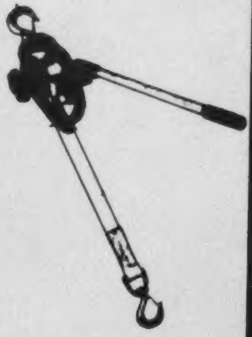
Hoists



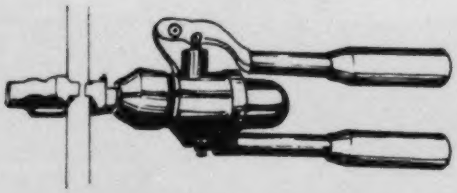
Cable Hoist



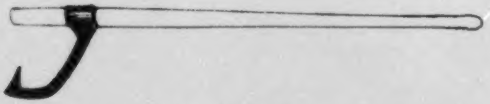
Chain Hoist



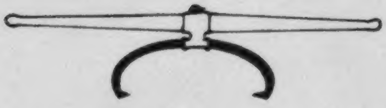
Insulated Strap Hoist



Compression Tool

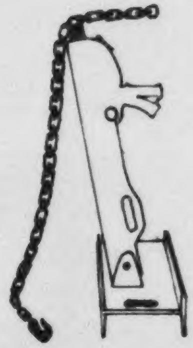


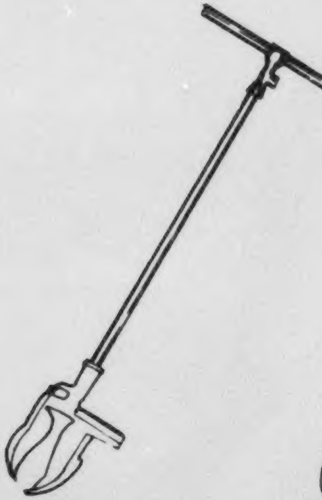
Cant Hook

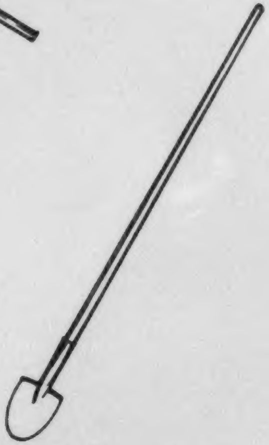


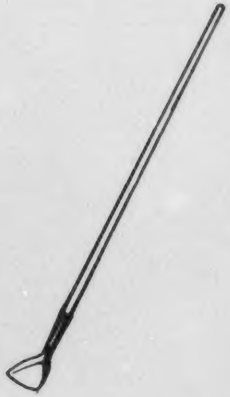
Pole Carrying Hook

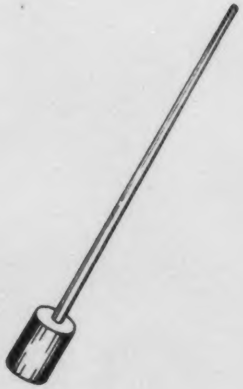
Overhead Construction Tools
(Continued)

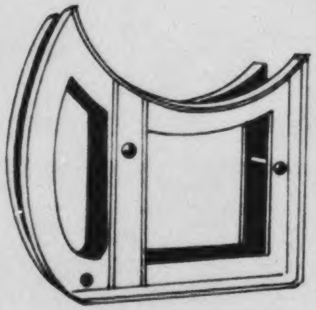

Pole Jack

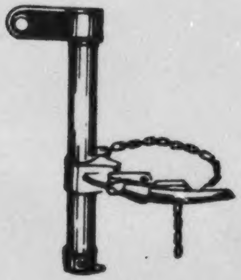

Anchor Auger

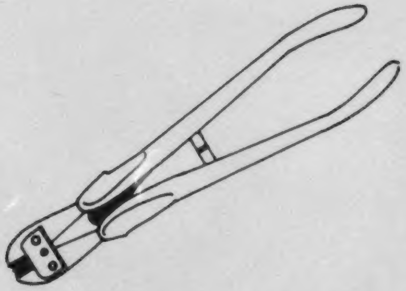

Digging Shovel

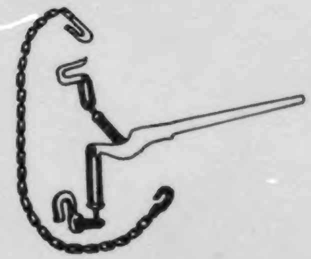

Digging Spoon


Tamp

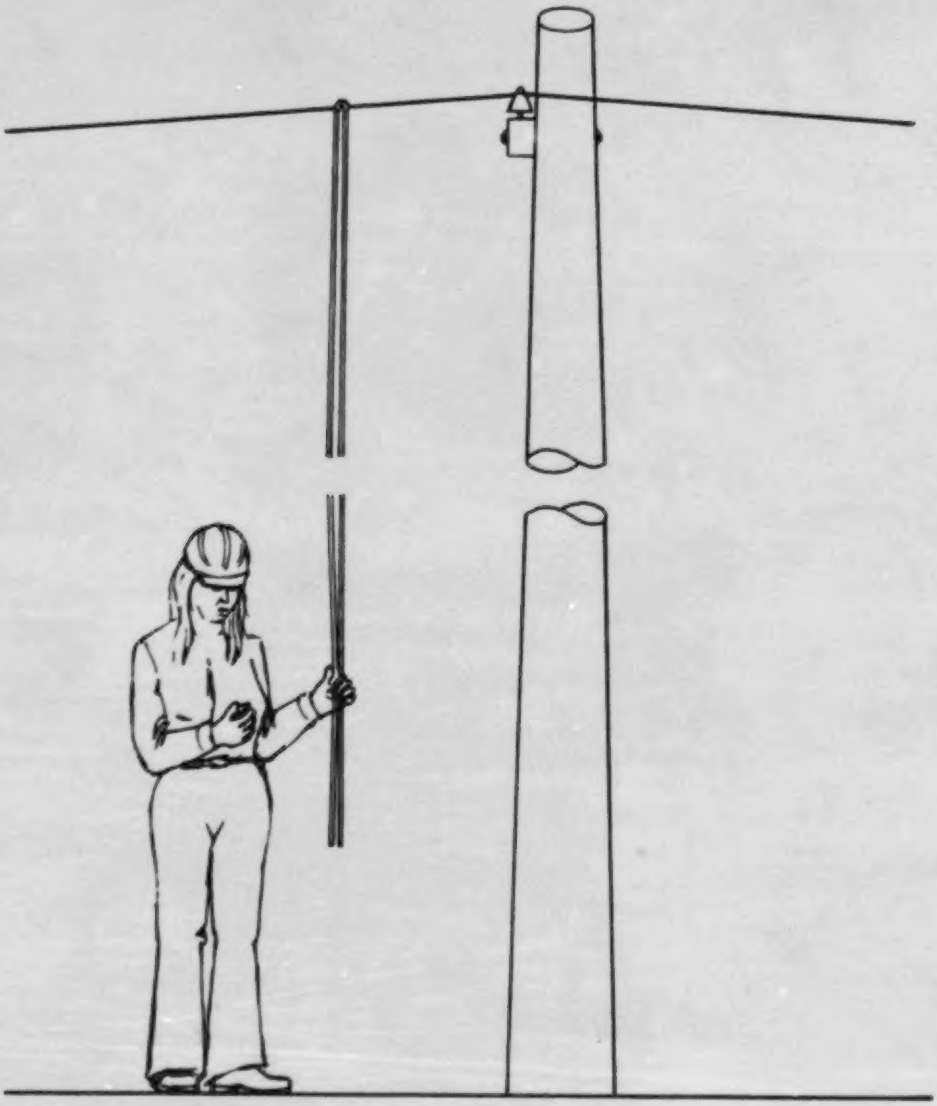

Pole Framing Gin


Transformer Gin

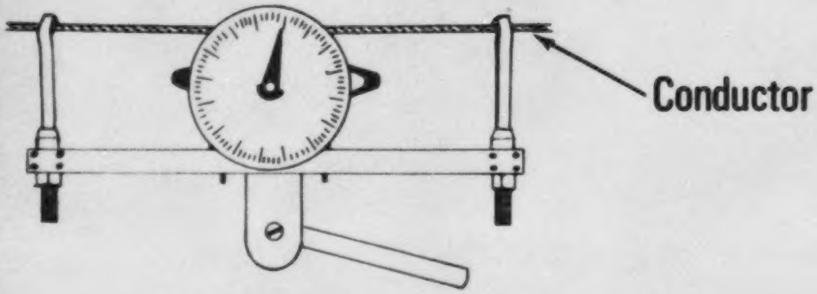

Bolt Cutters


Load Binder and Chain

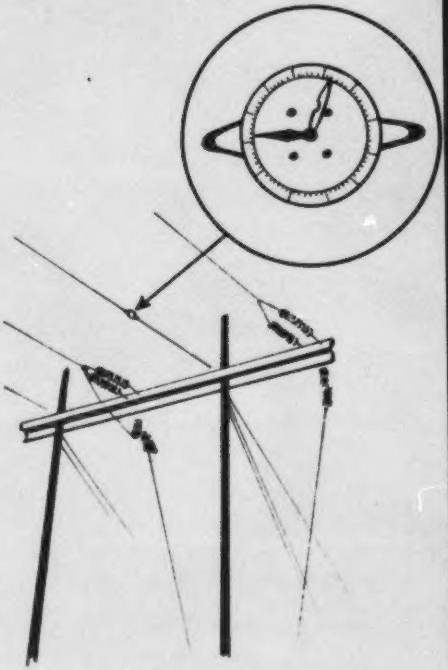
Checking Sag by Return Wave

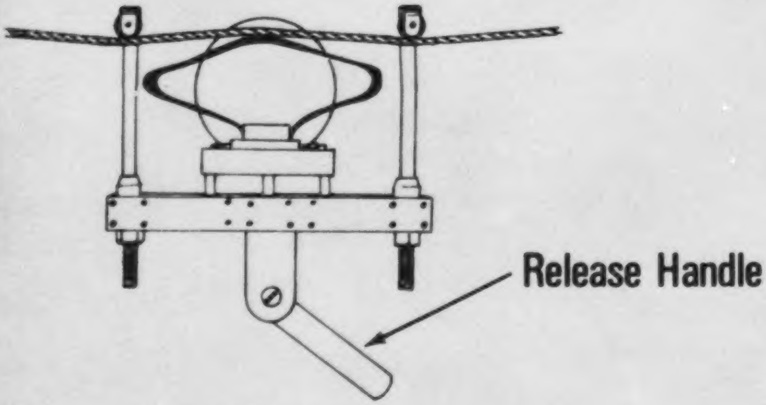


Dynamometer



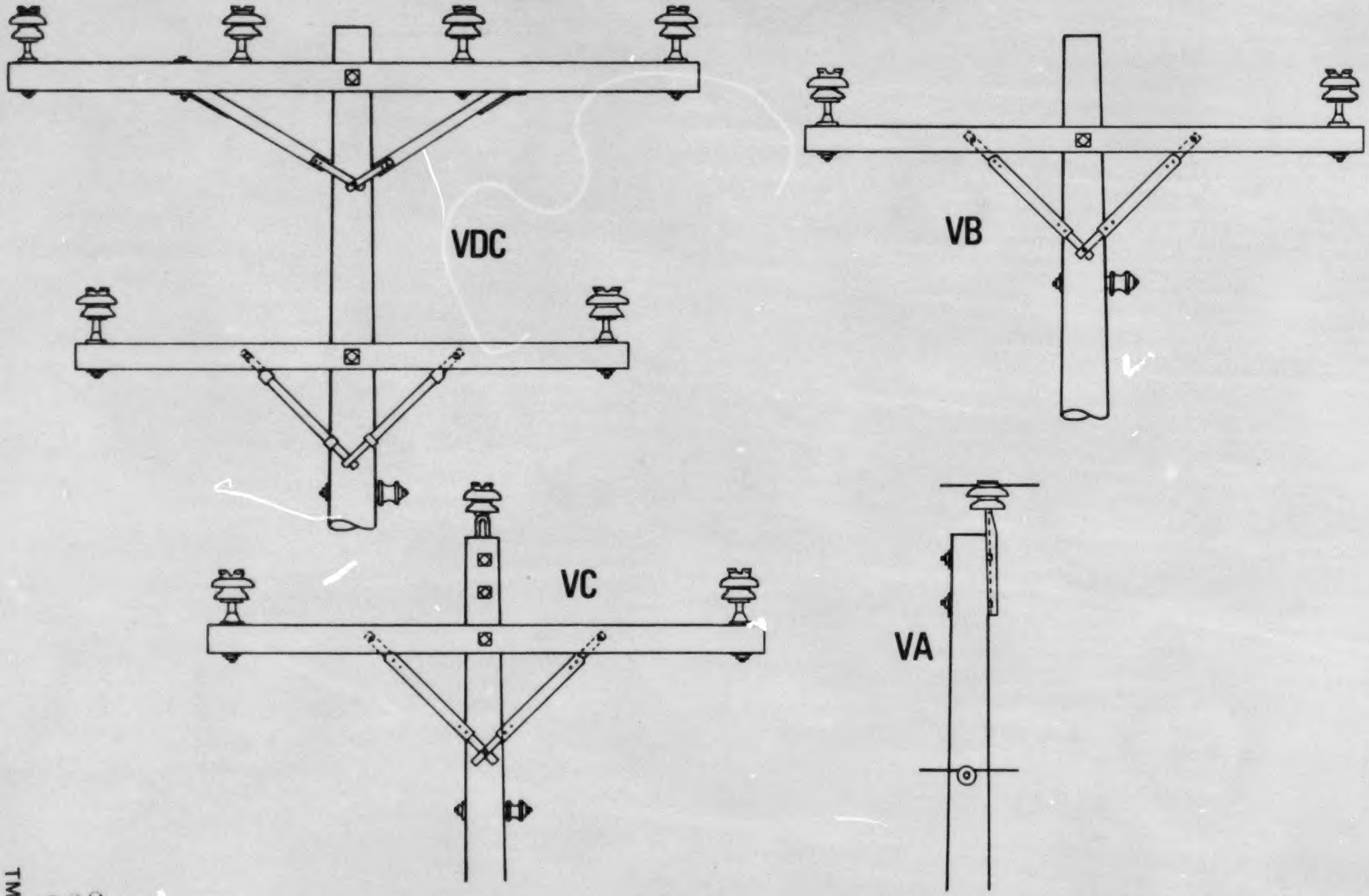
FRONT VIEW



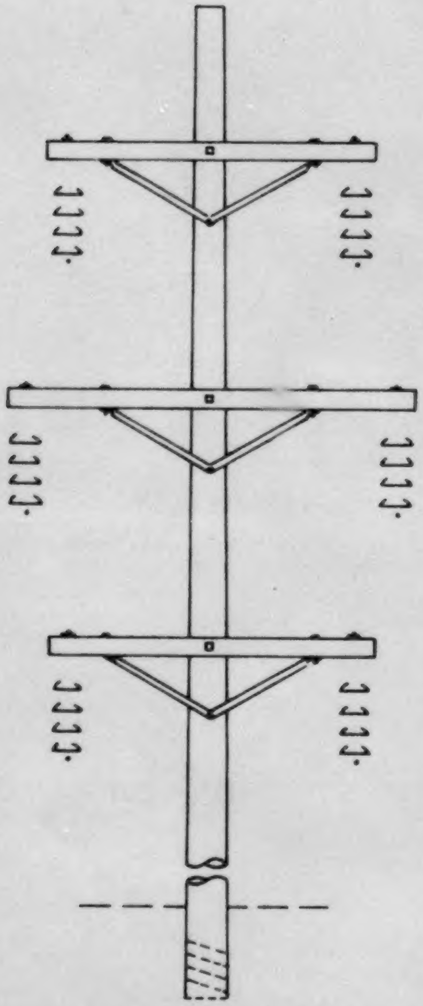


REAR VIEW

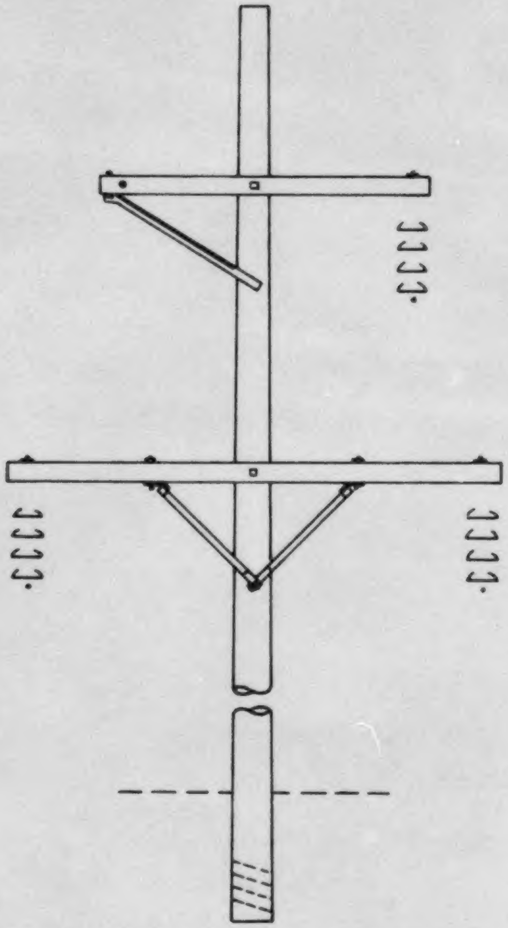
Types of Construction



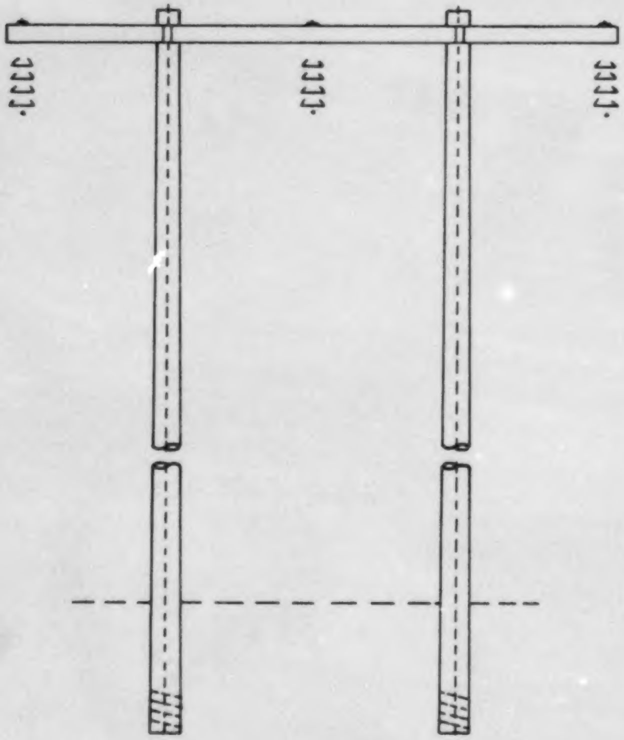
Transmission Line Structures



69 kV Double Circuit
Single Pole



69 kV Single Circuit
Single Pole

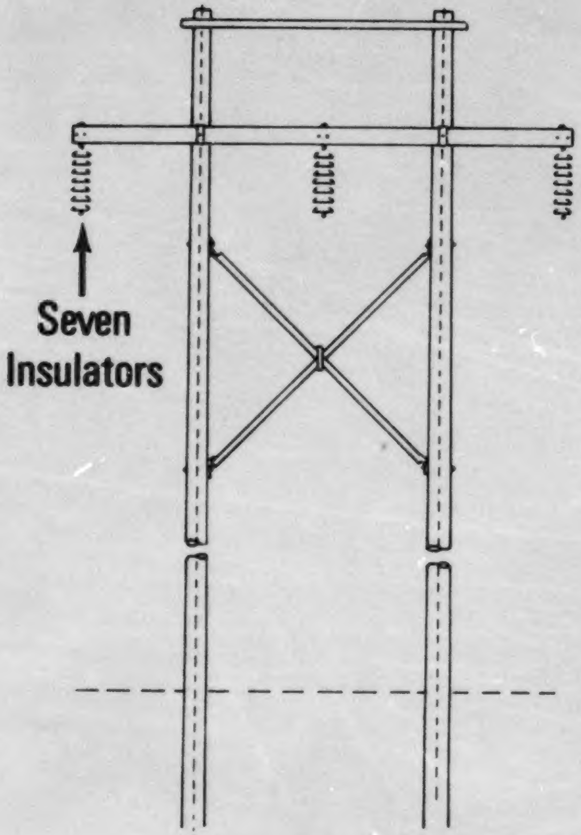


69 kV Two Pole Single Circuit

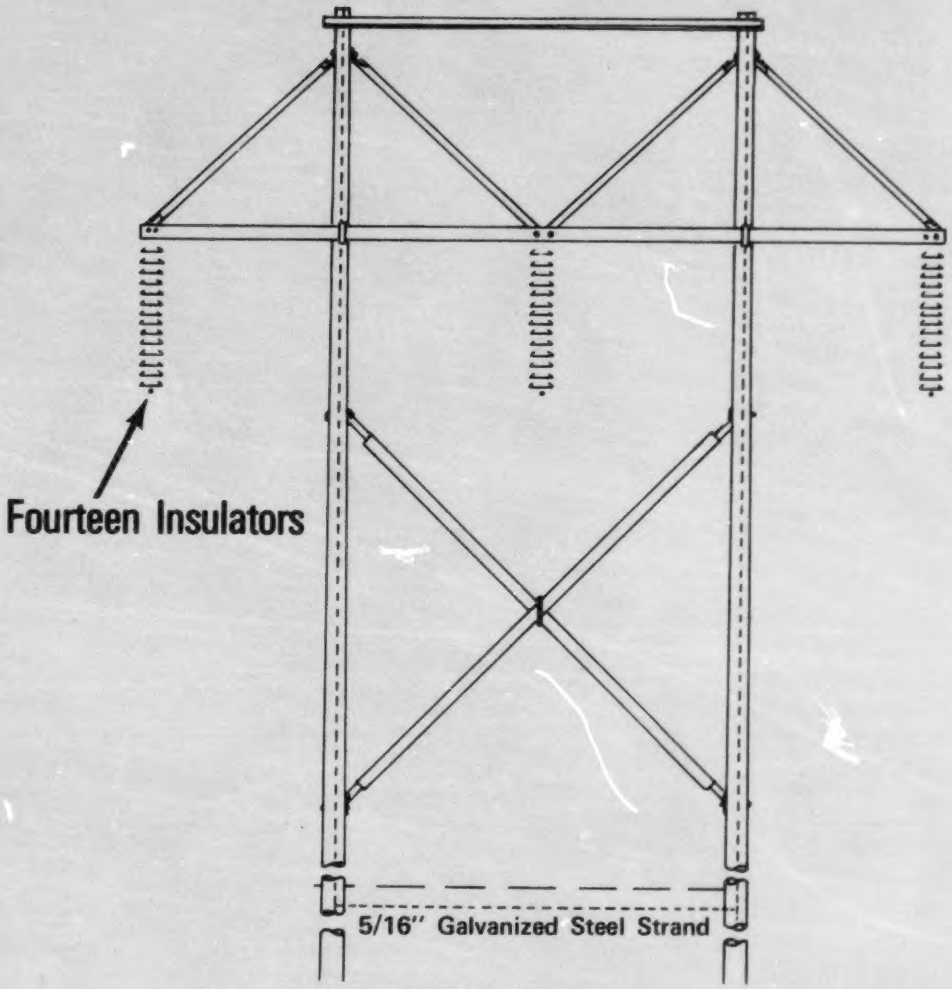
TM 18

PLT - 237-B

Transmission Line Structures

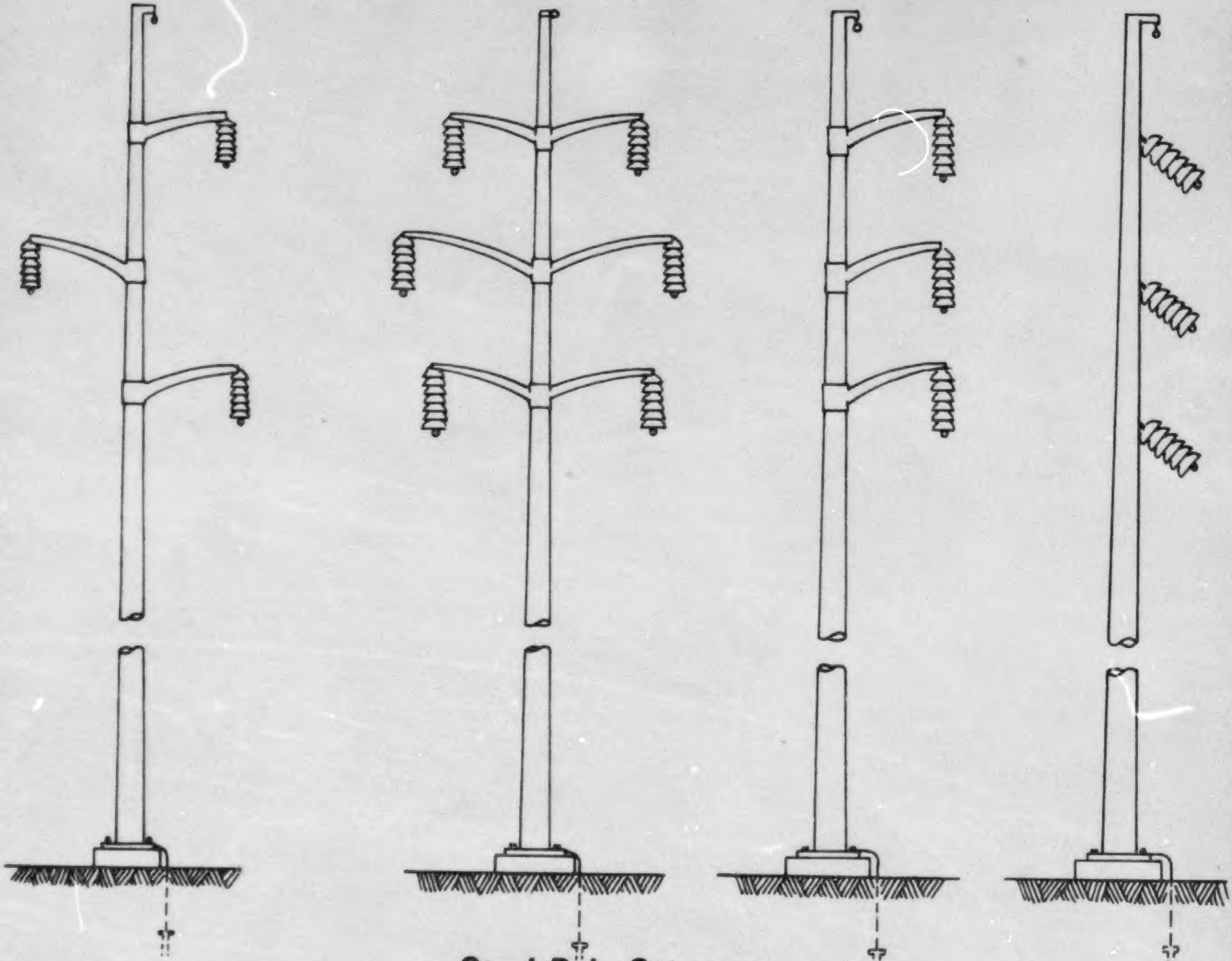


115 kV H-Frame



230 kV H-Frame

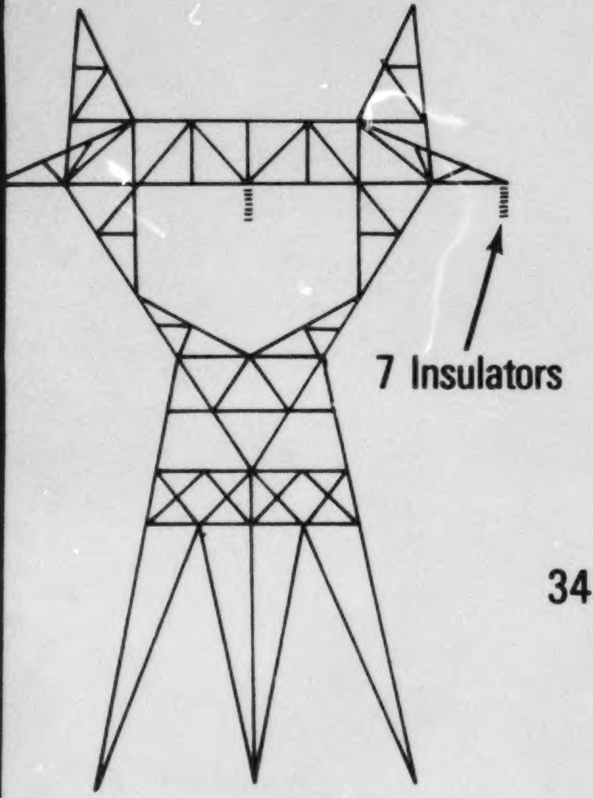
Transmission Line Structures



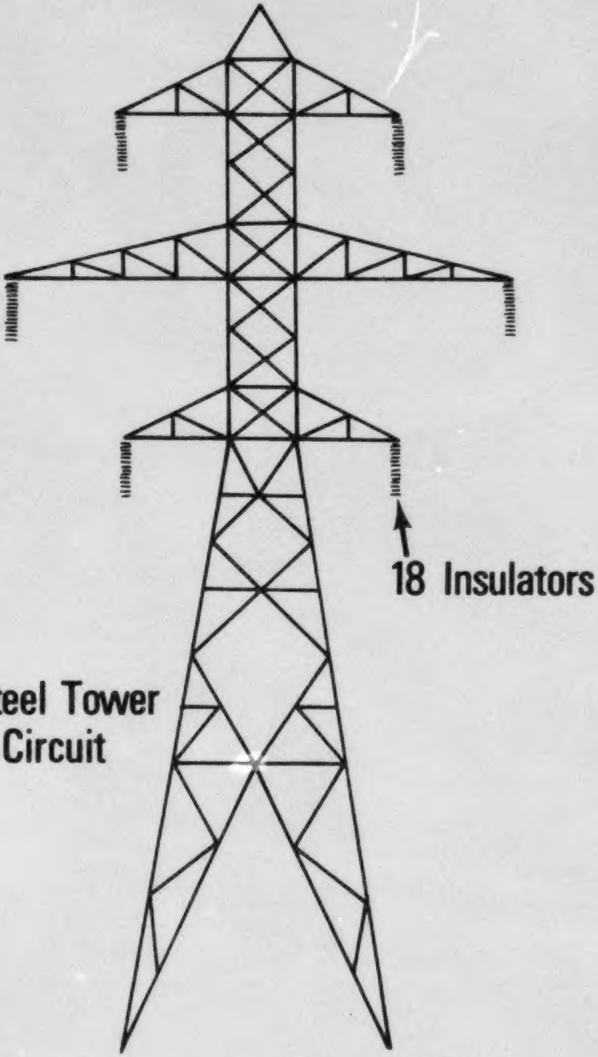
Steel Pole Structures

These structures may be used for 69 through 230 kV. The higher the voltage the greater the separation between conductors and between the conductors and the structure.

Transmission Line Structures



115 kV Steel Tower
Single Circuit



345 kV Steel Tower
Double Circuit

OVERHEAD CONSTRUCTION
UNIT V

TEST

NAME ______________________________ SCORE ______________________

1. Match the terms on the right to the correct definitions. (Answers to "a" through "k" are on this page.)

______a. Pole used to elevate guy wire over roadways or obstructions

______b. Strong steel wire used to hold against conductor strain between pole and anchor

______c. Marking found on pole which gives the kind of wood, the date pole was treated, the manufacturer, and the length and class of pole

______d. Place in the line where the conductor is connected to an attachment and may or may not continue to other poles

______e. Area at the top of a pole which is planed and drilled for crossarm or hardware attachment

______f. Short length of pole strapped and bolted to an existing pole for support

______g. Removing bark, trimming, gaining, boring holes, and attaching grounds and hardware

______h. Aligning the holes in a pole with the conductor or at an angle to the conductor

______i. To lean a pole against conductor strain

______j. Using a long, round pole with a pointed metal spike on one end to plumb or hold a pole straight while setting

______k. Section of pole or a treated plank used to brace a pole

1. Pole key
2. Piking
3. Framing
4. Canting
5. Rake
6. Dead end
7. Stub pole
8. Pole brand
9. Guy strand
10. Overhead stub
11. Pole gain

______l. Distance between a straight line and where the conductor is recommended to be hung

______m. Pulley mounted on a crossarm or pole to string conductor through when stringing long runs of conductor

______n. Soft wood planks nailed or strapped across conductor reels to protect the conductor

______o. Line which carries power over great distances between generation plant and substations

______p. Line which carries 2,300 to 34,500 volts of power throughout urban and rural areas

12. Lagging
13. Sag
14. Dolly
15. Distribution line
16. Transmission line

2. Match the materials on the right to the correct uses. (Answers for "a" through "i" are on this page.)

______a. Attaches hardware and equipment to poles

______b. Used in heavier distribution and transmission line construction and for pole stubbing

______c. Used to bolt heavy-duty crossarm braces to crossarm

______d. Used to bolt standard crossarm braces to crossarm

______e. Used to bolt crossarms together when two or more crossarms are used

______f. Used where a dead end in the primary or neutral is constructed

______g. Used on the back side of an eye bolt when a double dead end is constructed

______h. Used in the neutral position on primary structure for attaching the neutral conductor

______i. Used to hold conductor an extended distance from pole

1. 3/8" carriage bolt
2. Double arming bolt
3. Eye nut
4. 1/2" machine bolt
5. Eye bolt
6. 3/4" machine bolt
7. Upset bolt
8. Double upset bolt
9. 5/8" machine bolt

______j. Used to secure conductor at a dead end

______k. Used to hold a spool insulator

______l. Used with both large and small clevises for service dead ends and neutral dead ends and on upset bolts

______m. Used for screwing into wood or clamping around pipe

______n. Used with all bolts when nut does not tighten against other hardware

______o. Used to connect eye bolts or eye bolt and eye nut together

______p. Used to dead end or suspend conductor on angle poles or is hung below crossarm to suspend conductor on higher voltage systems

______q. Used with a rod for attaching guy wire to hold against conductor strain

______r. Used on a crossarm to attach an insulator

______s. Connects conductors together which are not under strain

______t. Used on all bolts

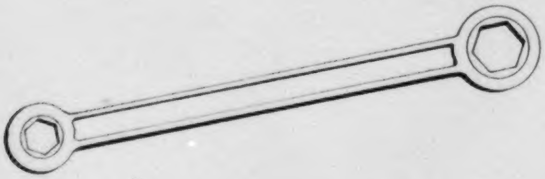
______u. Bolts to top of pole to hold insulator

______v. Fastens to the bottom of a pole for a ground

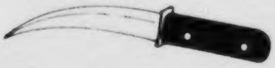
______w. Used with guy wire on overhead guys

10. Dead-end shoe
11. Thimble eye bolt
12. Insulator pin
13. Locknut
14. Connector
15. Suspension insulator (bell)
16. Square washer
17. Anchor shackle
18. Anchor
19. Spool insulator
20. Wire holder
21. Butt plate
22. Pole top pin
23. Clevis

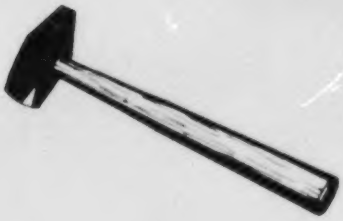
3. Identify the following hand tools used in overhead construction.



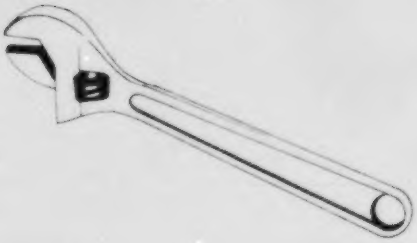
a. ____________________



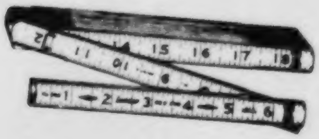
b. ____________________



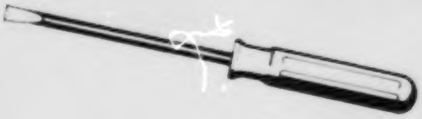
c. ____________________



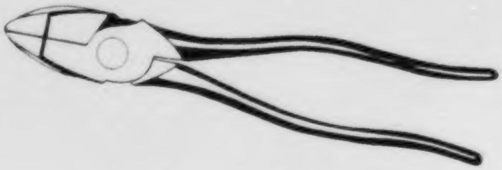
d. ____________________



e. ____________________



f. ____________________



g. ____________________

4. Match the hand tools on the right to their specific uses.

_____a. Cuts and serves soft wire

_____b. Drives and removes screws

_____c. Drives lag screws and steeples

_____d. Loosens and tightens connectors, bolts, and nuts

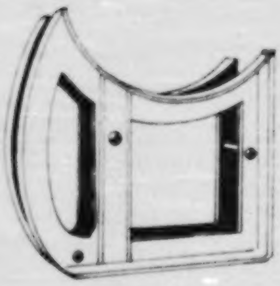
_____e. Tightens nuts and connectors

_____f. Removes insulation

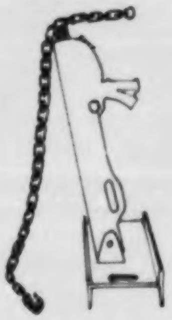
_____g. Measures spacing for material

1. Screwdriver
2. Skinning knife
3. Ratchet wrench
4. Line technician's hammer
5. Adjustable wrench
6. Line technician's pliers
7. Folding wood rule

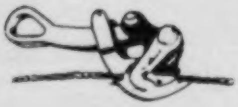
5. Identify the following overhead construction tools.



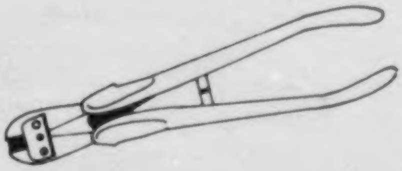
a. ____________________



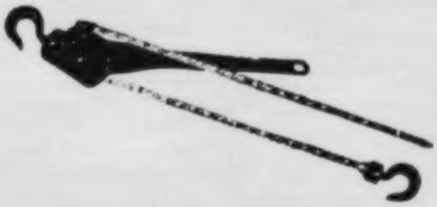
b. ____________________



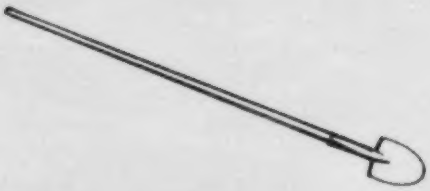
c. ____________________



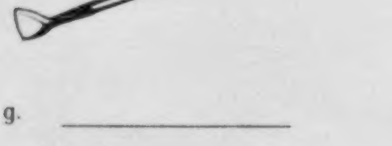
d. ____________________



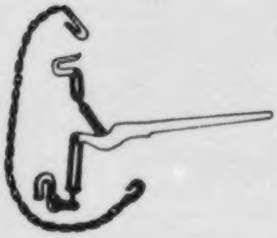
e. ________________

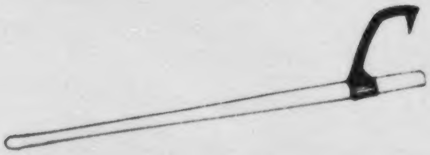


f. ________________

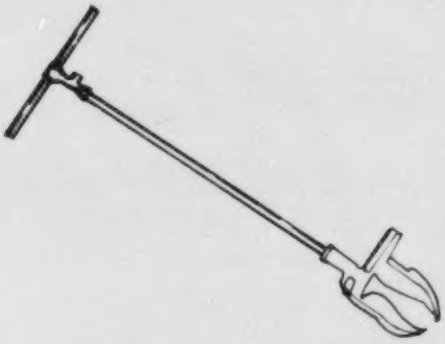


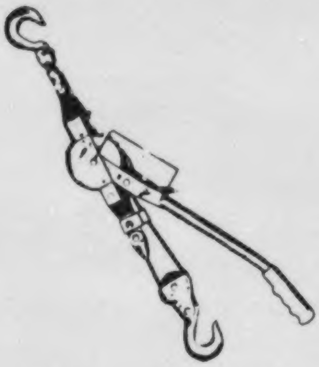
g. ________________



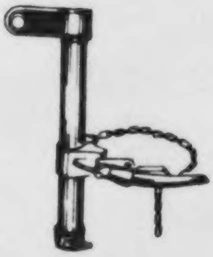


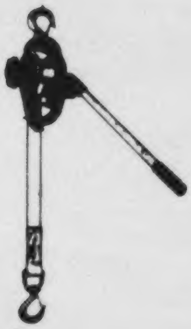
h. ______________________ i. ______________________



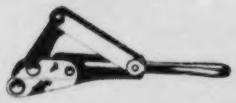


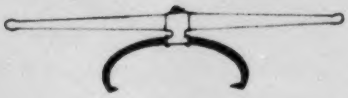
j. ______________________ k. ______________________





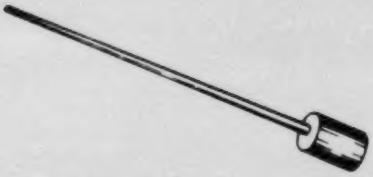
l. ______________________ m. ______________________

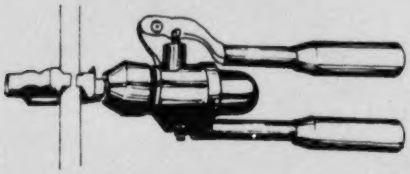




n. ____________________

o. ____________________





p. ____________________

q. ____________________

6. Match the overhead construction tools on the right to their specific uses.

_____a. Attaches to conductor and is used with hoist or block and tackle to pull conductor or guy wire

_____b. Pulls tension on conductor or guy wire

_____c. Turns poles

_____d. Carries poles

_____e. Pulls or straightens poles

_____f. Digs anchor holes

_____g. Digs pole holes

_____h. Removes loose dirt from pole holes

_____i. Packs soil around poles or on anchors

_____j. Elevates and holds pole while framing material is being installed

_____k. Attaches to pole to hold block and tackle for lowering or raising transformer

_____l. Cuts guy wire and heavy conductor

1. Pole carrying hook
2. Anchor auger
3. Tamp
4. Bolt cutters
5. Cant hook
6. Digging shovel
7. Pole framing gin
8. Pole jack
9. Load binder and chain
10. Digging spoon
11. Pulling grip
12. Hoist
13. Compression tool
14. Transformer gin

______m. Binds poles to truck or pole trailer

______n. Crimps sleeves and connectors

7. List four elements of overhead construction.

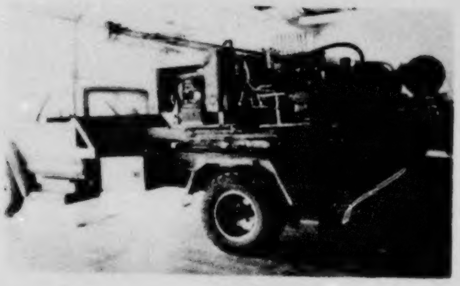
a. ______________________________

b. ______________________________

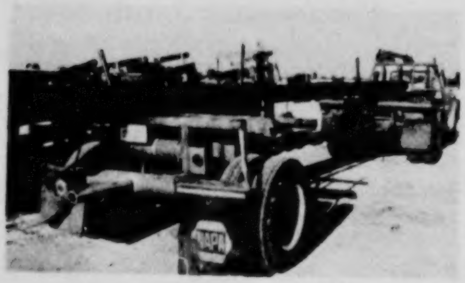
c. ______________________________

d. ______________________________

8. Identify the following overhead construction equipment.



a. ____________________



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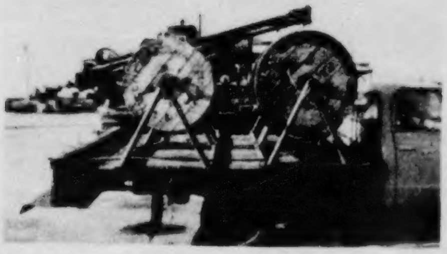
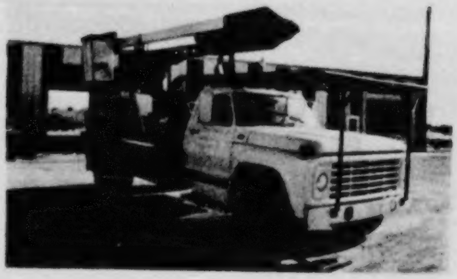


c. ____________________



d. ____________________

9. Match the equipment on the right to the specific uses.

______a.	Digs pole and anchor holes; sets and pulls poles	1.	Pole truck and trailer
______b.	Carries poles and materials to job site	2.	Basket truck
______c.	Carries reels of primary and service conductor to job site	3.	Hole digger derrick
______d.	Assists line technician in reaching and working near energized conductors	4.	Conductor-stringing truck and trailer

10. Select from the following chart the correct depth to set the poles listed below.

Length of Pole (feet)	Setting in Soil (feet)	Setting in All Solid Rock (feet)
20	4.0	3.0
25	5.0	3.5
30	5.5	3.5
35	6.0	4.0
40	6.0	4.0
45	6.5	4.5
50	7.0	4.5
55	7.5	5.0
60	8.0	5.0
65	8.5	
70	9.0	
75	9.5	
80	10.0	
85	10.5	
90	11.0	
95	11.0	
100	11.0	

Pole setting depth for lengths of 65 feet or more may be decreased from soil setting depth by two feet when pole is set in solid rock

________a. 35-foot pole in solid rock

________b. 40-foot pole in soil

________c. 80-foot pole in solid rock

________d. 30-foot pole in soil

11. List four methods used to sag conductor.

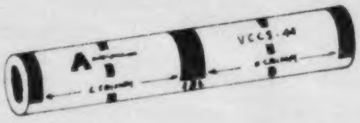
a. ______________________________

b. ______________________________

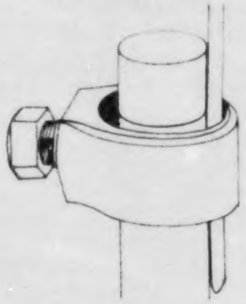
c. ______________________________

d. ______________________________

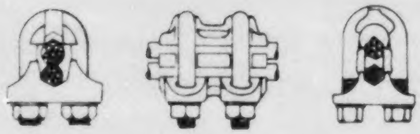
12. Identify the following connectors used in overhead construction.



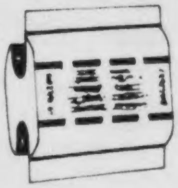
a. ______________



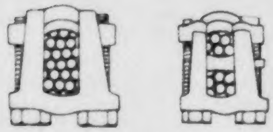
b. ______________



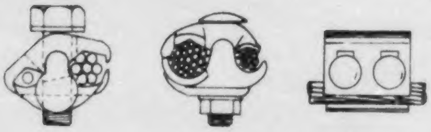
c. ______________



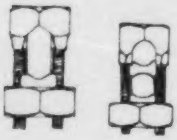
d. ______________



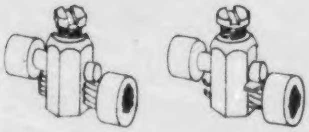
e. ______________



f. ______________



g. ______________



h. ______________

13. Match the types of construction on the right to the correct descriptions.

_____a. Three primary conductors with one neutral conductor

_____b. One primary conductor with one neutral conductor

_____c. Two primary conductors with one neutral conductor

_____d. Six primary conductors with one neutral conductor

1. VA
2. VB
3. VC
4. VDC

14. List two steps to install a pole key.

a. ______________________________

b. ______________________________

15. State the correct procedure for installing a ground rod.

a. ______________________________

b. ______________________________

16. Arrange in order the steps to follow when framing a pole by writing the number of the step in the blank provided.

_____a. Install crossarm, if required

_____b. Check pole ground for clearance between pole ground and hardware

_____c. Roll pole onto framing gin with cant hook

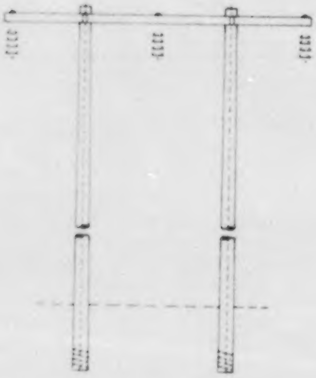
_____d. Place steeples 2' apart on remainder of pole

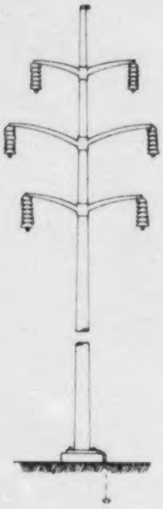
_____e. String and steeple pole ground to pole

_____f. Place steeples 6" apart from ground level to 8' above ground and 8' from top of pole

_____g. Install required hardware with square washers and locknuts on all bolts

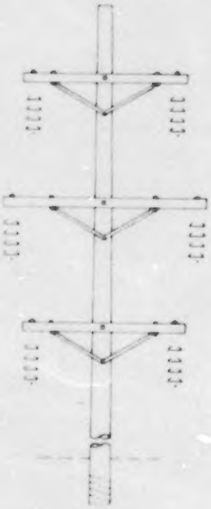
17. Identify the following transmission line structures.

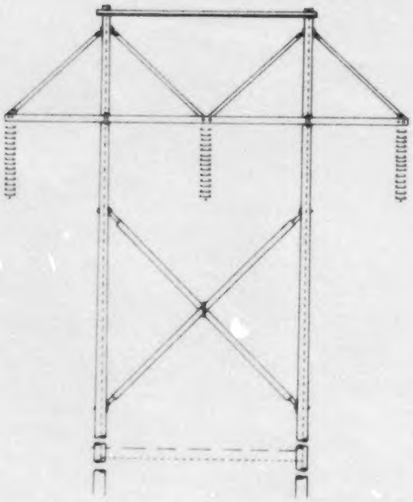




a. ____________________

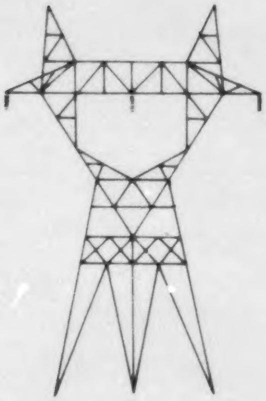
b. ____________________



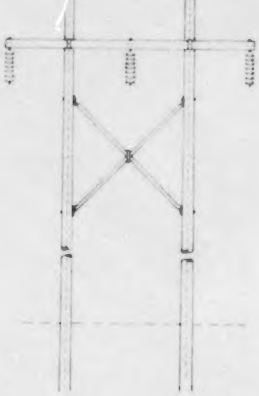


c. ____________________

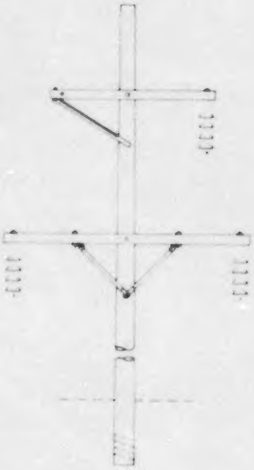
d. ____________________



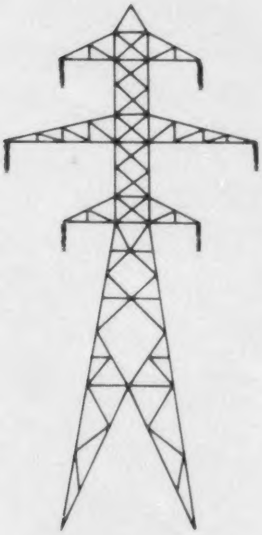
e. ______________________



f. ______________________



g. ______________________



h. ______________________

OVERHEAD CONSTRUCTION
UNIT V

ANSWERS TO TEST

1. Match the terms on the right to the correct definitions. (Answers to "a" through "k" are on this page.)

10 a. Pole used to elevate guy wire over roadways or obstructions

9 b. Strong steel wire used to hold against conductor strain between pole and anchor

8 c. Marking found on pole which gives the kind of wood, the date pole was treated, the manufacturer, and the length and class of pole

6 d. Place in the line where the conductor is connected to an attachment and may or may not continue to other poles

11 e. Area at the top of a pole which is planed and drilled for crossarm or hardware attachment

7 f. Short length of pole strapped and bolted to an existing pole for support

3 g. Removing bark, trimming, gaining, boring holes, and attaching grounds and hardware

4 h. Aligning the holes in a pole with the conductor or at an angle to the conductor

5 i. To lean a pole against conductor strain

2 j. Using a long, round pole with a pointed metal spike on one end to plumb or hold a pole straight while setting

1 k. Section of pole or a treated plank used to brace a pole

1. Pole key
2. Piking
3. Framing
4. Canting
5. Rake
6. Dead end
7. Stub pole
8. Pole brand
9. Guy strand
10. Overhead stub
11. Pole gain

13 l. Distance between a straight line and where the conductor is recommended to be hung

14 m. Pulley mounted on a crossarm or pole to string conductor through when stringing long runs of conductor

12 n. Soft wood planks nailed or strapped across conductor reels to protect the conductor

16 o. Line which carries power over great distances between generation plant and substations

15 p. Line which carries 2,300 to 34,500 volts of power throughout urban and rural areas

12. Lagging
13. Sag
14. Dolly
15. Distribution line
16. Transmission line

2. Match the materials on the right to the correct uses. (Answers for "a" through "i" are on this page.)

9 a. Attaches hardware and equipment to poles

6 b. Used in heavier distribution and transmission line construction and for pole stubbing

4 c. Used to bolt heavy-duty crossarm braces to crossarm

1 d. Used to bolt standard crossarm braces to crossarm

2 e. Used to bolt crossarms together when two or more crossarms are used

5 f. Used where a dead end in the primary or neutral is constructed

3 g. Used on the back side of an eye bolt when a double dead end is constructed

7 h. Used in the neutral position on primary structure for attaching the neutral conductor

8 i. Used to hold conductor an extended distance from pole

1. 3/8" carriage bolt
2. Double arming bolt
3. Eye nut
4. 1/2" machine bolt
5. Eye bolt
6. 3/4" machine bolt
7. Upset bolt
8. Double upset bolt
9. 5/8" machine bolt

10 j. Used to secure conductor at a dead end

23 k. Used to hold a spool insulator

19 l. Used with both large and small clevises for service dead ends and neutral dead ends and on upset bolts

20 m. Used for screwing into wood or clamping around pipe

16 n. Used with all bolts when nut does not tighten against other hardware

17 o. Used to connect eye bolts or eye bolt and eye nut together

15 p. Used to dead end or suspend conductor on angle poles or is hung below crossarm to suspend conductor on higher voltage systems

18 q. Used with a rod for attaching guy wire to hold against conductor strain

12 r. Used on a crossarm to attach an insulator

14 s. Connects conductors together which are not under strain

13 t. Used on all bolts

22 u. Bolts to top of pole to hold insulator

21 v. Fastens to the bottom of a pole for a ground

11 w. Used with guy wire on overhead guys

10. Dead-end shoe
11. Thimble eye bolt
12. Insulator pin
13. Locknut
14. Connector
15. Suspension insulator (bell)
16. Square washer
17. Anchor shackle
18. Anchor
19. Spool insulator
20. Wire holder
21. Butt plate
22. Pole top pin
23. Clevis

3. Identify the following hand tools used in overhead construction.

   a. Ratchet wrench

   b. Skinning knife

   c. Line technician's hammer

   d. Adjustable wrench

   e. Folding wood rule

   f. Screwdriver

   g. Line technician's pliers

4. Match the hand tools on the right to their specific uses.

6 a. Cuts and serves soft wire
1 b. Drives and removes screws
4 c. Drives lag screws and steeples
3 d. Loosens and tightens connectors, bolts, and nuts
5 e. Tightens nuts and connectors
2 f. Removes insulation
7 g. Measures spacing for material

1. Screwdriver
2. Skinning knife
3. Ratchet wrench
4. Line technician's hammer
5. Adjustable wrench
6. Line technician's pliers
7. Folding wood rule

5. Identify the following overhead construction tools.

a. Pole framing gin
b. Pole jack
c. Guy grip
d. Bolt cutters
e. Chain hoist
f. Digging shovel
g. Digging spoon
h. Load binder and chain
i. Cant hook
j. Anchor auger
k. Cable hoist
l. Transformer gin
m. Insulated strap hoist
n. Wire grip
o. Pole carrying hook
p. Tamp
q. Compression tool

6. Match the overhead construction tools on the right to their specific uses.

   __11__ a. Attaches to conductor and is used with hoist or block and tackle to pull conductor or guy wire

   __12__ b. Pulls tension on conductor or guy wire

   __5__ c. Turns poles

   __1__ d. Carries poles

   __8__ e. Pulls or straightens poles

   __2__ f. Digs anchor holes

   __6__ g. Digs pole holes

   __10__ h. Removes loose dirt from pole holes

   __3__ i. Packs soil around poles or on anchors

   __7__ j. Elevates and holds pole while framing material is being installed

   __14__ k. Attaches to pole to hold block and tackle for lowering or raising transformer

   __4__ l. Cuts guy wire and heavy conductor

   __9__ m. Binds poles to truck or pole trailer

   __13__ n. Crimps sleeves and connectors

   1. Pole carrying hook
   2. Anchor auger
   3. Tamp
   4. Bolt cutters
   5. Cant hook
   6. Digging shovel
   7. Pole framing gin
   8. Pole jack
   9. Load binder and chain
   10. Digging spoon
   11. Pulling grip
   12. Hoist
   13. Compression tool
   14. Transformer gin

7. List four elements of overhead construction.

   a. Pole loading, hauling, framing, setting, and removing

   b. Anchor setting

   c. Guy make-up and pulling

   d. Conductor stringing, laying up, sagging, and tying in

8. Identify the following overhead construction equipment.

   a. Hole digger derrick

   b. Pole truck and trailer

   c. Conductor-stringing truck

   d. Basket truck

9. Match the equipment on the right to the specific uses.

3	a.	Digs pole and anchor holes; sets and pulls poles	1.	Pole truck and trailer
1	b.	Carries poles and materials to job site	2.	Basket truck
4	c.	Carries reels of primary and service conductor to job site	3.	Hole digger derrick
2	d.	Assists line technician in reaching and working near energized conductors	4.	Conductor-stringing truck and trailer

10. Select from the following chart the correct depth to set the poles listed below.

Length of Pole (feet)	Setting in Soil (feet)	Setting in All Solid Rock (feet)
20	4.0	3.0
25	5.0	3.5
30	5.5	3.5
35	6.0	4.0
40	6.0	4.0
45	6.5	4.5
50	7.0	4.5
55	7.5	5.0
60	8.0	5.0
65	8.5	
70	9.0	
75	9.5	
80	10.0	
85	10.5	
90	11.0	
95	11.0	
100	11.0	

Pole setting depth for lengths of 65 feet or more may be decreased from soil setting depth by two feet when pole is set in solid rock

4.0 a. 35-foot pole in solid rock

6.0 b. 40-foot pole in soil

8.0 c. 80-foot pole in solid rock

5.5 d. 30-foot pole in soil

11. List four methods used to sag conductor.

a. Sighting

b. Return wave

c. Transit

d. Dynamometer

12. Identify the following connectors used in overhead construction.

    a. Compression sleeve

    b. Ground rod clamp

    c. U-bolt clamp

    d. Compression fitting

    e. Two bolt

    f. Center bolt

    g. Split bolt

    h. Service entrance

13. Match the types of construction on the right to the correct descriptions.

    3 a. Three primary conductors with one neutral conductor

    1 b. One primary conductor with one neutral conductor

    2 c. Two primary conductors with one neutral conductor

    4 d. Six primary conductors with one neutral conductor

    1. VA
    2. VB
    3. VC
    4. VDC

14. List two steps to install a pole key.

    a. Dig trench the required length at a right angle to conductor strain

    b. Insert pole key in trench so that top of key is 12" below ground

15. State the correct procedure for installing a ground rod.

    a. Dig trench 14" deep and 30" long parallel with overhead conductors

    b. Drive ground rod into undisturbed soil 2' from pole

16. Arrange in order the steps to follow when framing a pole by writing the number of the step in the blank provided.

    6 a. Install crossarm, if required

    7 b. Check pole ground for clearance between pole ground and hardware

    1 c. Roll pole onto framing gin with cant hook

4 d. Place steeples 2' apart on remainder of pole

2 e. String and steeple pole ground to pole

3 f. Place steeples 6" apart from ground level to 8' above ground and 8' from top of pole

5 g. Install required hardware with square washers and locknuts on all bolts

17. Identify the following transmission line structures.

a. 69 kV two pole single circuit

b. 69 kV-230 kV steel pole single and double circuit

c. 69 kV single pole double circuit

d. 230 kV H-frame

e. 115 kV steel tower single circuit

f. 115 kV H-frame

g. 69 kV single pole single circuit

h. 345 kV steel tower double circuit

UNDERGROUND DISTRIBUTION CONSTRUCTION
UNIT VI

UNIT OBJECTIVE

After completion of this unit, the student should be able to identify equipment and materials used in underground construction and be able to observe precautions in handling and splicing cable. The student should be able to make a cable splice. This knowledge will be evidenced through demonstration and by scoring 85 percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms associated with underground construction to the correct definitions.
2. Identify equipment used in underground construction.
3. Match various types of equipment to the specific uses.
4. List general requirements for underground construction.
5. Arrange in order the correct procedure for installing cable.
6. List precautions to observe when handling underground cable.
7. Select from a list methods of marking cable for identification.
8. List methods used to locate and identify a utility ditch.
9. Identify equipment used to terminate primary cable on a pole.
10. State the requirement for grounding underground equipment.
11. List hazards which may be encountered in underground construction.
12. List precautions to observe when splicing or terminating cable.
13. Select from a list the tools used in underground construction.
14. Demonstrate the ability to:
    a. Make a proper splice in secondary cable.
    b. Make a proper splice in primary cable.

UNDERGROUND DISTRIBUTION CONSTRUCTION
UNIT VI

SUGGESTED ACTIVITIES

I. Suggested activities for instructor:

   A. Provide student with objective sheet.

   B. Provide student with information and job sheets.

   C. Make transparencies.

   D. Discuss unit and specific objectives.

   E. Discuss information sheet.

   F. Demonstrate and discuss the procedures outlined in the job sheets.

   G. Give test.

II. Unit references:

   A. Rural Electrification Administration. *Specifications and Drawings for Underground Electric Distribution.* REA Form 806. Washington, D.C.: U.S. Department of Agriculture, January 1972.

   B. Kurtz, Edwin B., and Shoemaker, Thomas M. *The Lineman's and Cableman's Handbook.* 5th ed. New York: McGraw-Hill Book Co., 1976.

III. Film--"Ditching." Charles Machine Works. Perry, Oklahoma.

UNDERGROUND DISTRIBUTION CONSTRUCTION
UNIT VI

INFORMATION SHEET

I. Terms and definitions

A. Service cable--Underground cable which runs from transformer or pedestal to metering point (Transparency 1)

B. Secondary cable--Heavy underground cable which runs from transformer to pedestal (Transparency 1)

C. Primary cable--High voltage cable which runs from source of power to transformer or protective equipment (Transparency 2)

D. Riser--Length of conduit installed on a pole or on a building to protect underground cable above the ground (Transparency 3)

E. Pedestal--Buried or partially buried enclosure used as a point of connection for secondary and service cable (Transparency 4)

F. Connector block--Aluminum or copper block used to connect conductors (Transparency 4)

G. Terminator--Unit installed on the ends of primary cable (Transparency 5)

H. Concentric neutral--Conductor spiraled around insulated conductor or conductors in both high and low voltage cable (Transparency 6)

(NOTE: The concentric neutral may be either a round wire or flat strap conductor.)

I. Stress--Electric flux lines which concentrate at the ends of high voltage cable and deteriorate cable insulation (Transparency 7)

(NOTE: Stress will also concentrate at a splice which has not been protected with stress relief tape or at a void in the cable insulation.)

J. Stress cone--Cone or tape designed to disperse electric flux lines (Transparency 8)

K. Semi-conductor--Solid material that has electrical characteristics between that of a conductor and an insulator and is used for stress control

L. Underground distribution system--Area of housing or business fed by underground power lines (Transparency 9)

INFORMATION SHEET

M. Switching cabinet--Metal enclosure which contains equipment for changing circuit feeds or loads from one circuit to another (Transparency 10)

N. Vault--Fiber or concrete enclosure installed below grade to house transformer or switching gear (Transparency 10)

O. Feed-through bushing--Bushing used on transformers and switching gear for connecting elbow terminators (Transparency 10)

(NOTE: It is often called a "flower pot".)

II. Equipment used in underground construction

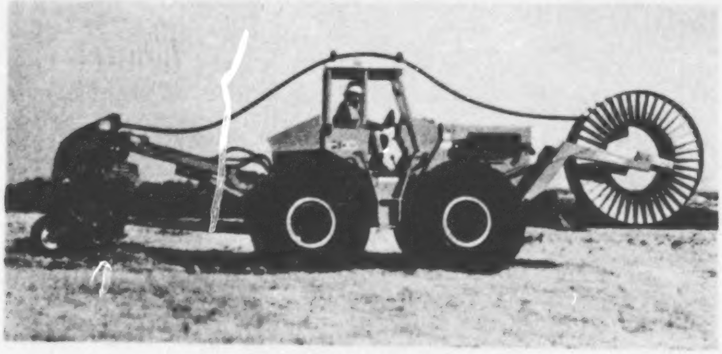
A. Small trencher with backfill blade

B. Large trencher with frost- and rock-cutting teeth

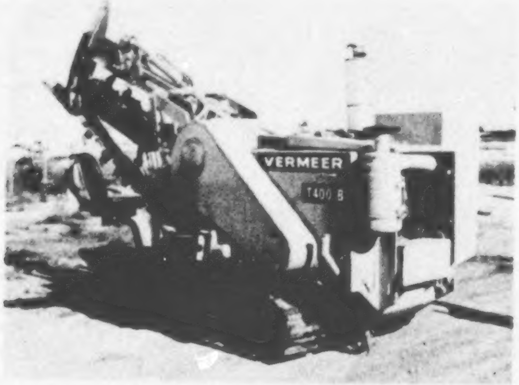
INFORMATION SHEET

C. Medium-sized trencher with cable plow attached

D. Large cable plow with cable reel attachment

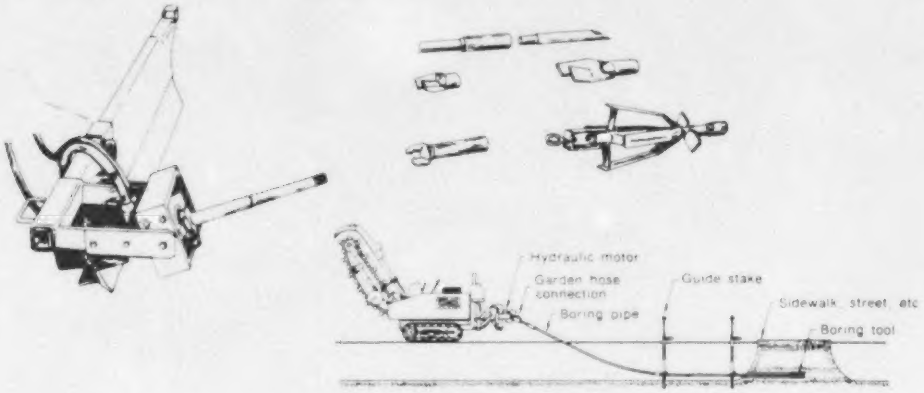


E. Large track mounted trencher

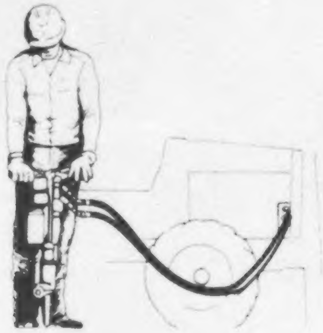


INFORMATION SHEET

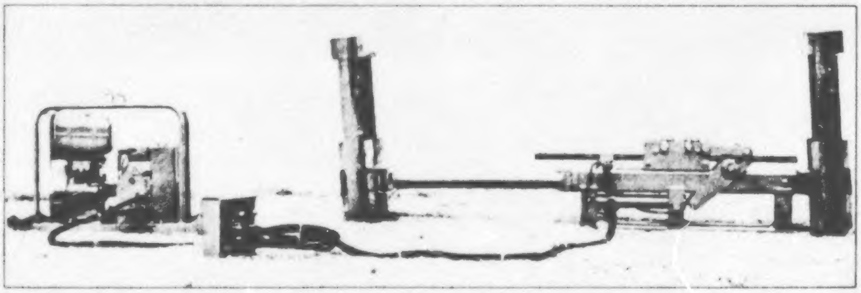
F. Boring machine and boring tools



G. Hydraulic jackhammer

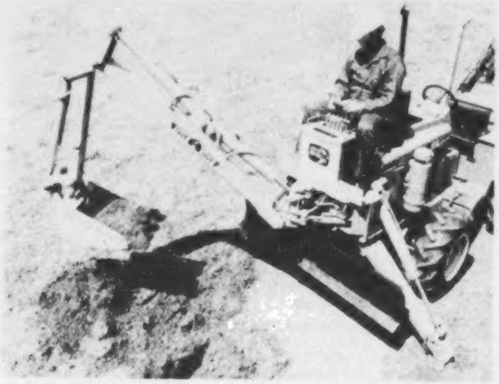


H. Hydraulic pipe pusher

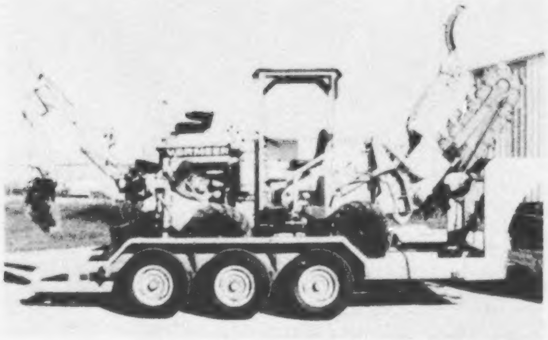


INFORMATION SHEET

I. Backhoe attachment



J. Equipment trailer



III. Uses of underground equipment

A. Small trencher with backfill blade--Trenches and backfills on short cable runs where great depth is not needed

B. Large trencher with frost- and rock cutting teeth--Trenches in frozen ground and in rocky structures

C. Medium-sized trencher with cable plow--Plows in cable where great depth is not needed or trenches when greater depth is necessary

D. Large cable plow with cable reel attachment--Plows in cable at great denth in open country where pipelines or other underground utilities are not present

E. Large track mounted trencher--Trenches in muddy or sandy areas where long cable runs are needed

INFORMATION SHEET

F. Boring machine and boring tools--Bores and reams out holes under streets and paved areas

G. Hydraulic jackhammer--Breaks up concrete or hard rock

H. Hydraulic pipe pusher--Pushes large diameter pipe under streets and paved areas

I. Backhoe attachment--Digs out large areas for working room

J. Equipment trailer--Transports equipment to and from job sites

IV. General requirements for underground construction

A. All work should be done in a thorough and skillful manner

B. All work should be done in accordance with plans and specifications

C. All work should meet or exceed the National Electrical Safety Code requirements

V. Procedure for installing cable

A. Lay conduit under streets

B. Lay out cable from moving vehicle

C. Inspect cable as it is removed from reel

D. Remove any objects from trench that might damage cable

E. Lay cable in trench by hand

F. Backfill

VI. Precautions to observe when handling underground cable

A. Handle carefully to avoid damage

(NOTE: When using equipment to load or unload reels of cable, do not allow the equipment, winch line, or bars to contact the cable.)

B. Avoid excessive bending

(NOTE: Cable should not have a bend which measures less than twelve times the diameter of the cable on the inside of the bend.)

C. Keep ends of cable sealed against moisture

D. Do not drag cable

INFORMATION SHEET

VII. Methods of marking cable for identification

(NOTE: It is extremely important that cable be marked properly for further identification. The cable should be marked as soon as it has been reeled out to avoid mismarking when more than one cable has been laid.)

A. Embossed plastic tape

B. Imprinted plastic tags

C. Corrosion-resistant metal tags

D. Colored plastic tape

VIII. Methods used to locate and identify utility ditch

A. Above-grade stake driven near ditch with name of utility attached

B. Plate inscribed with utility name placed over cable and flush with ground

C. Electronic voltage detector if cable is energized

D. Plastic tape inscribed with Caution: Electric Power Cable Below buried near surface of ditch

IX. Equipment used to terminate primary cable on a pole (Transparency 3)

A. Lightning arrester

B. Fuse cut-out

C. Terminator and bracket

D. Eye bolt

E. Shackle

F. Wire sock

G. Riser

H. Grounding bushing

X. Requirement for grounding underground equipment--All neutral conductors and groundable parts shall be interconnected

(NOTE: A telephone system which has underground lines near an electrical system may require a connection to the electrical system neutral.)

INFORMATION SHEET

XI. Hazards which may be encountered in underground construction

   A. Loop feed system

   B. Equipment that has not been properly grounded

   C. Regenerated charge that can exist on high voltage ungrounded cable

   (NOTE: Primary cable acts as a capacitor and may contain enough voltage to seriously injure anyone who carelessly handles ungrounded cable.)

   D. Other utilities

XII. Precautions to observe when splicing or terminating cable

   A. Ground the cable being repaired

   B. Use portable cover or shelter

   C. Keep material and cable dry

   D. Keep hands, material, and cable clean

   E. Clean surfaces with denatured alcohol

   F. Lubricate contacting surfaces with silicone grease

   (NOTE: Silicone grease is a good insulative material as well as a lubricant. It also helps seal out moisture.)

   G. Follow manufacturer's specifications

XIII. Tools used in underground construction

   A. Cable cutters

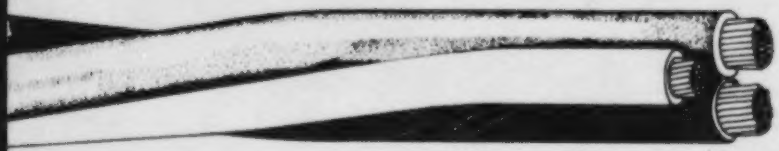
   B. Insulation removing tool

   C. Compression tool

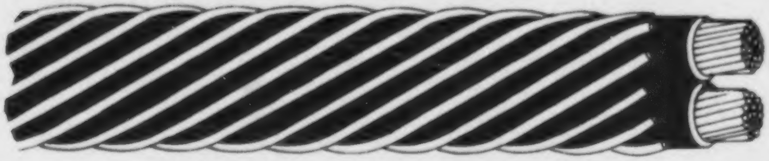
   D. Hand shovel

   E. Trench cleaning spoon

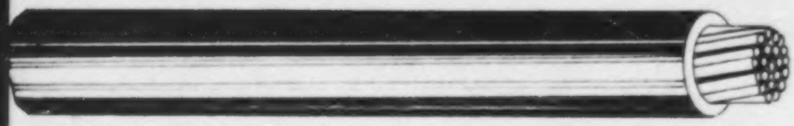
Secondary And Service Cable



Triplexed

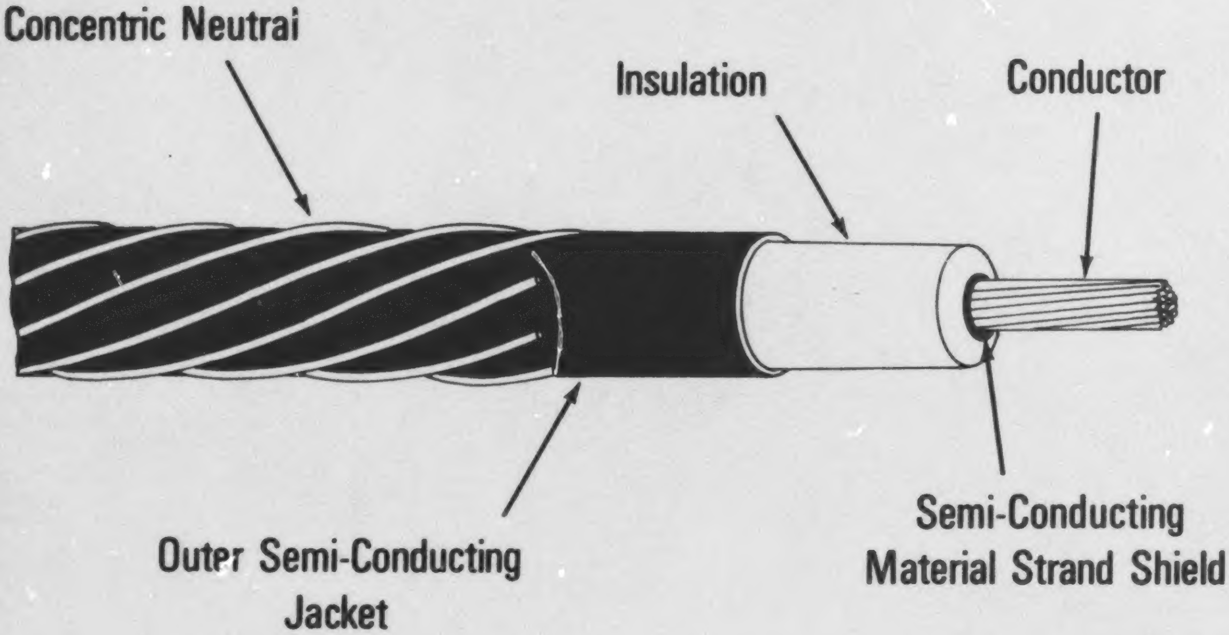


Parallel



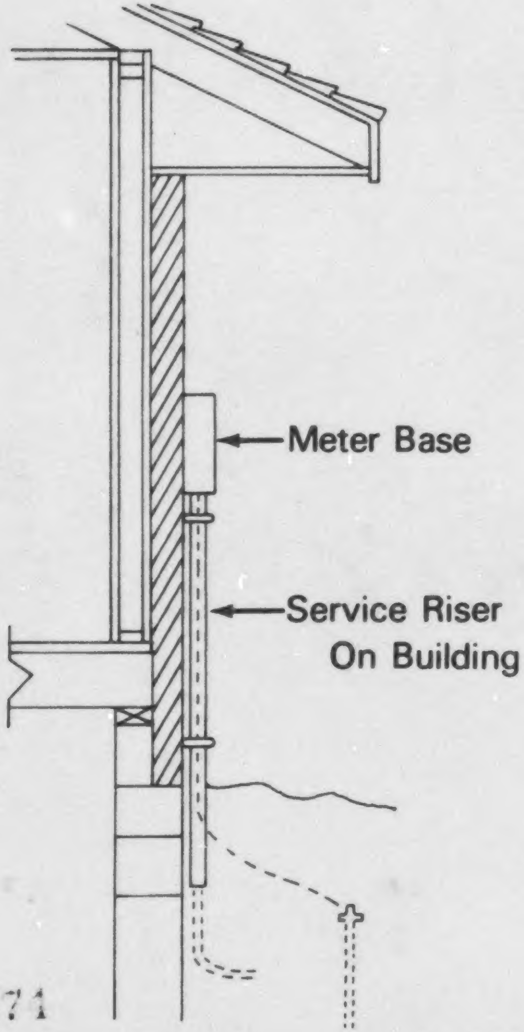
Single Conductor

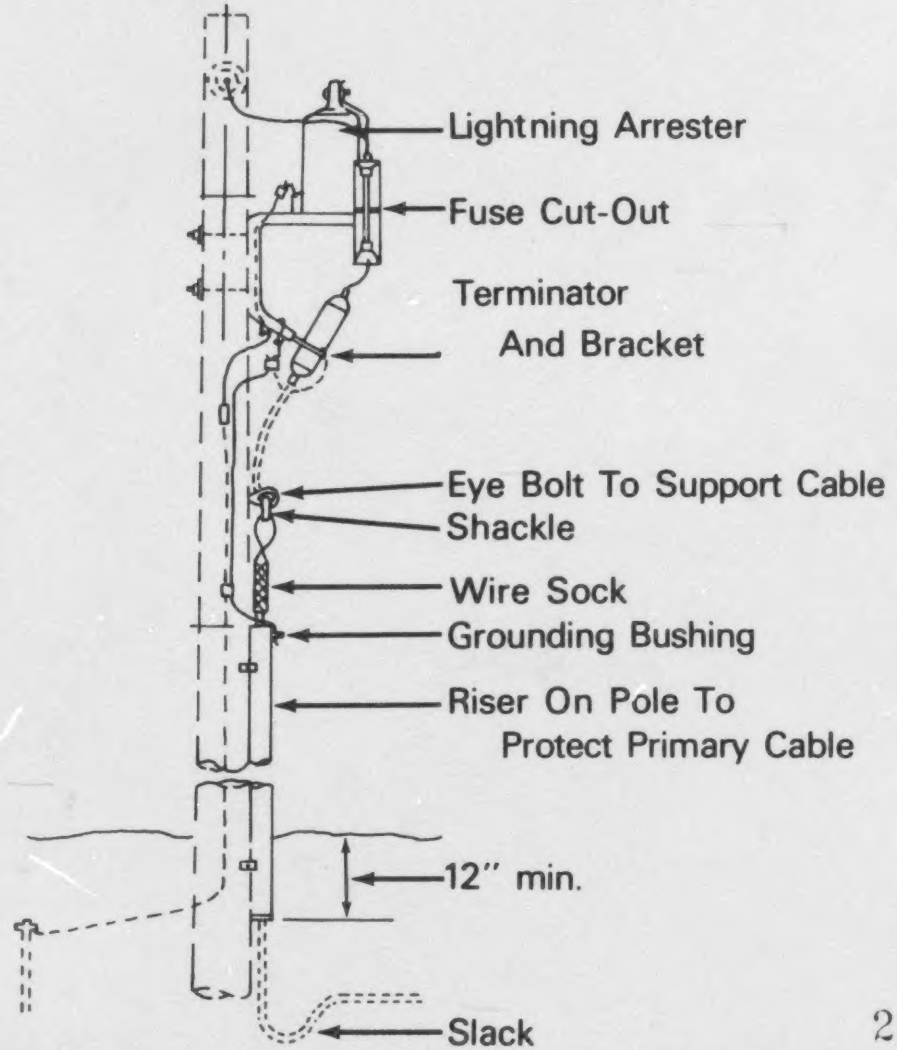
Primary Cable


Concentric Neutrai
Insulation
Conductor
Outer Semi-Conducting Jacket
Semi-Conducting Material Strand Shield

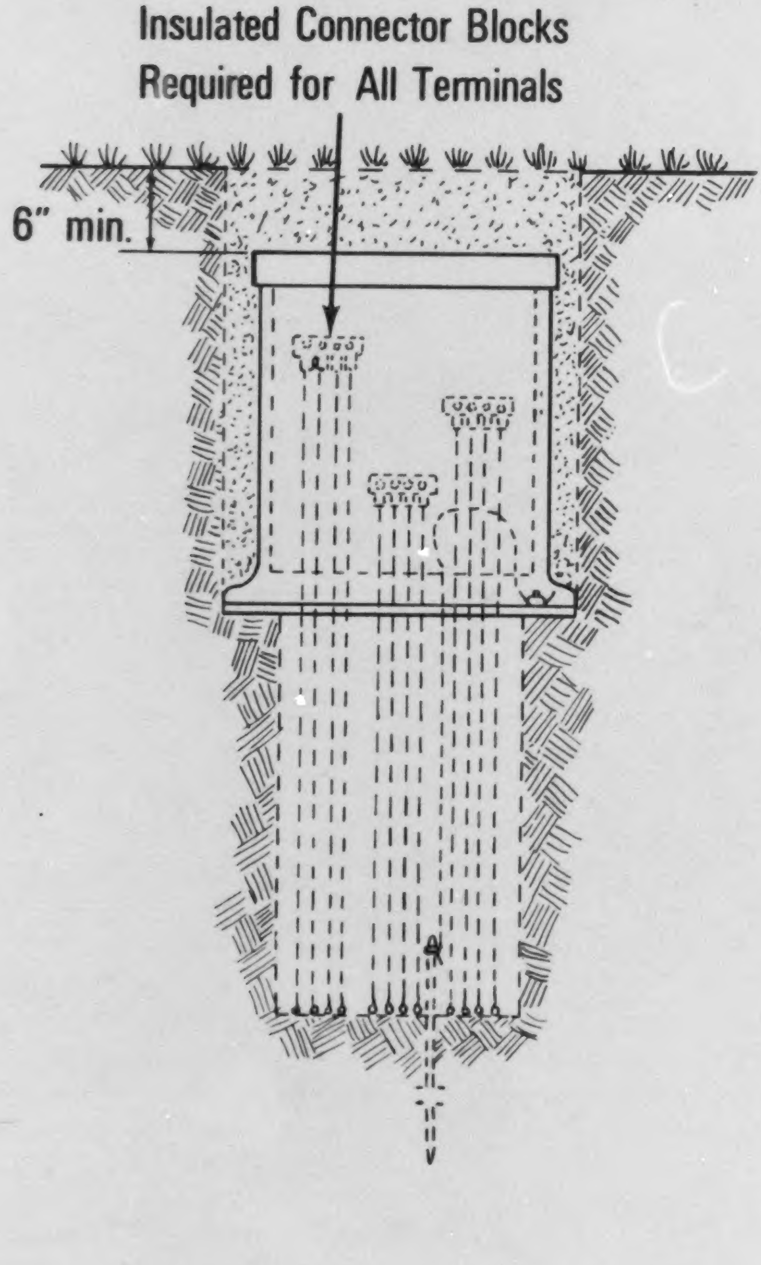
Risers

Risers On Building And Pole Shown With Arrester, Fuse And Terminator

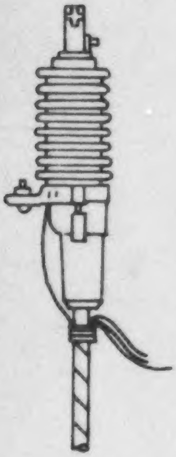




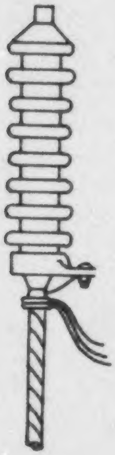
Connector Blocks Installed In Pedestal



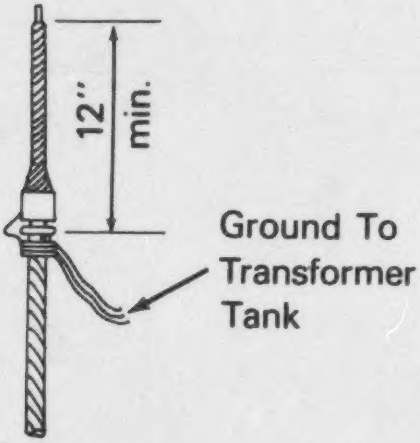
Terminators



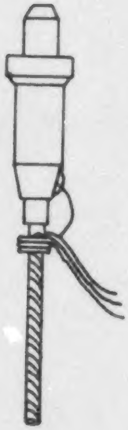
Porcelain



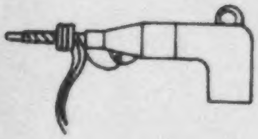
Synthetic Rubber



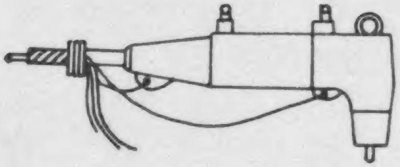
Indoor Type



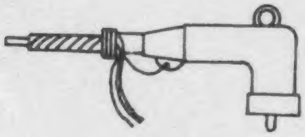
Cable Lead Termination



Non-Load Break Elbow Termination

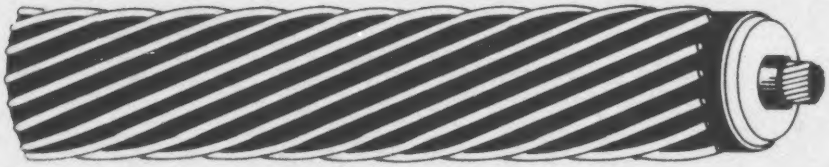


Fused Elbow Termination

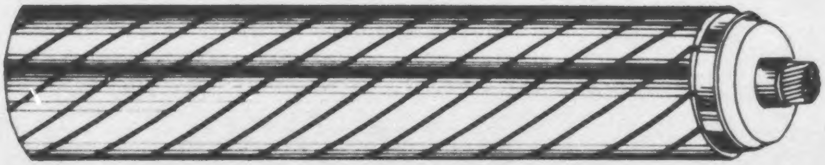


Load Break Elbow Termination

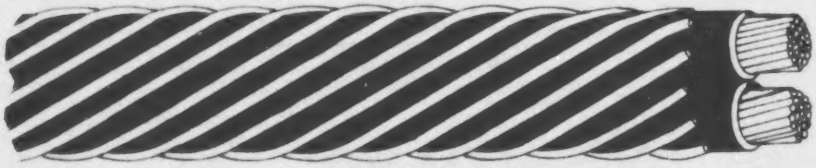
Concentric Neutrals



High Voltage Cable



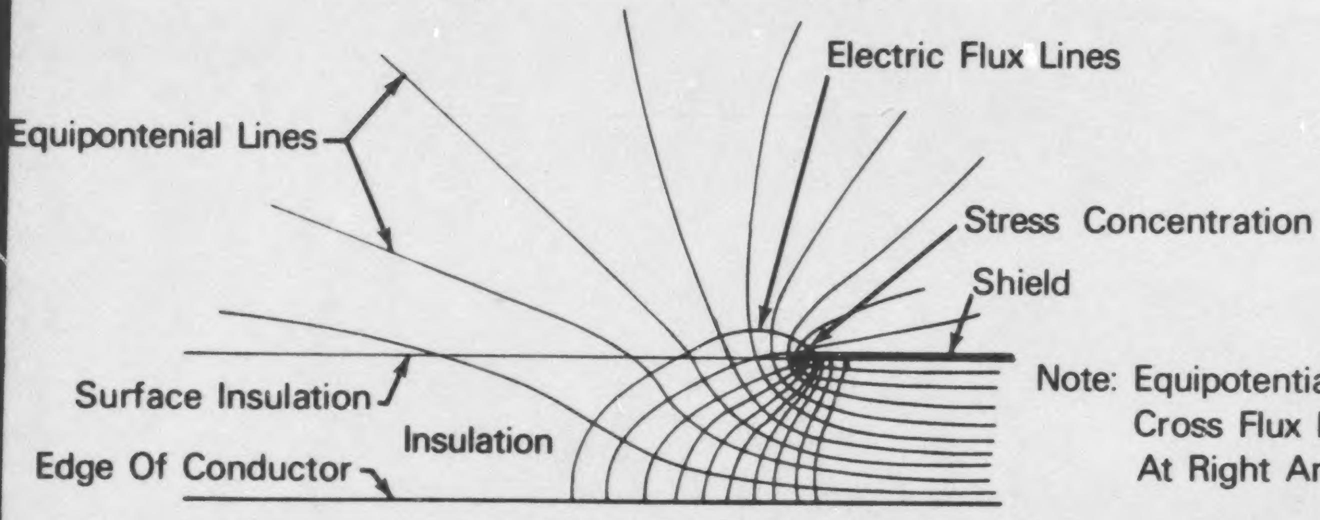
Note: REA Recommends That All Low Voltage Cables Be Insulated Rather Than Using A Concentric Neutral Type Cable.



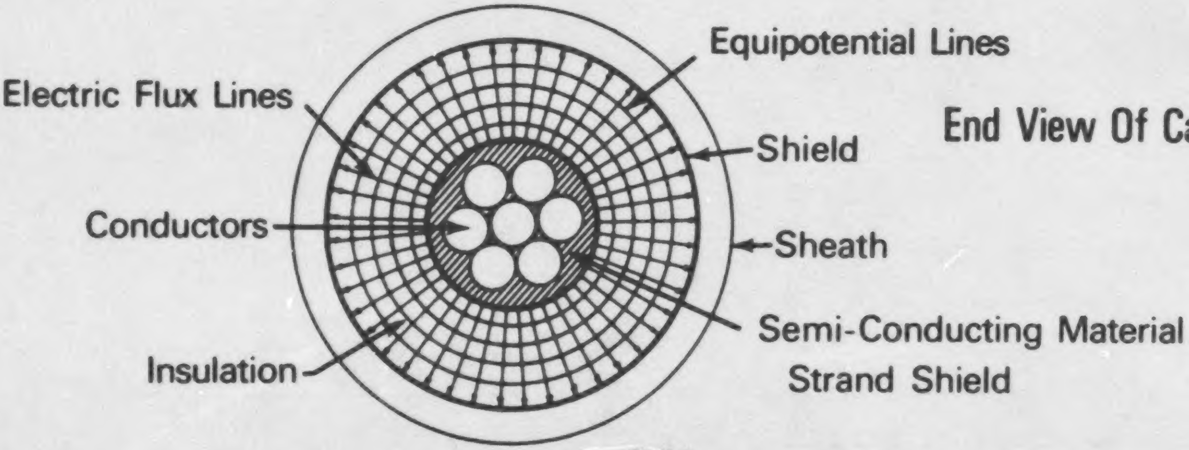
Low Voltage Cable

Stress

Cut-Away Section Of Cable Without Stress Relief



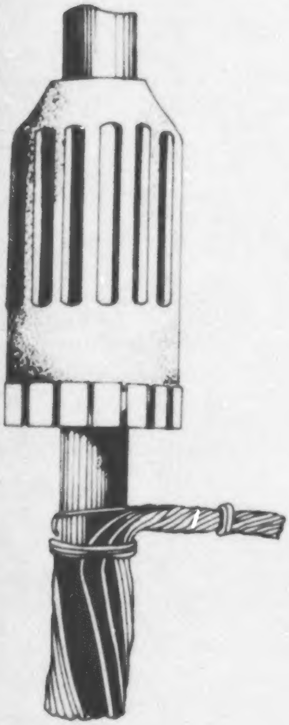
Note: Equipotential Lines
Cross Flux Lines
At Right Angles

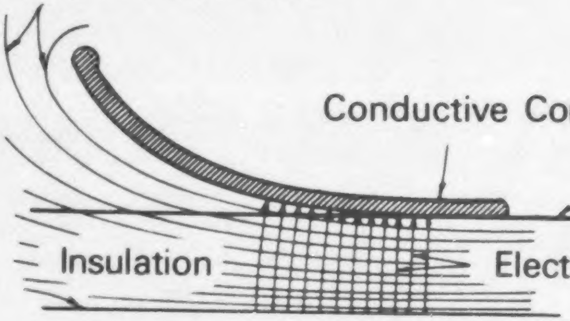


End View Of Cable

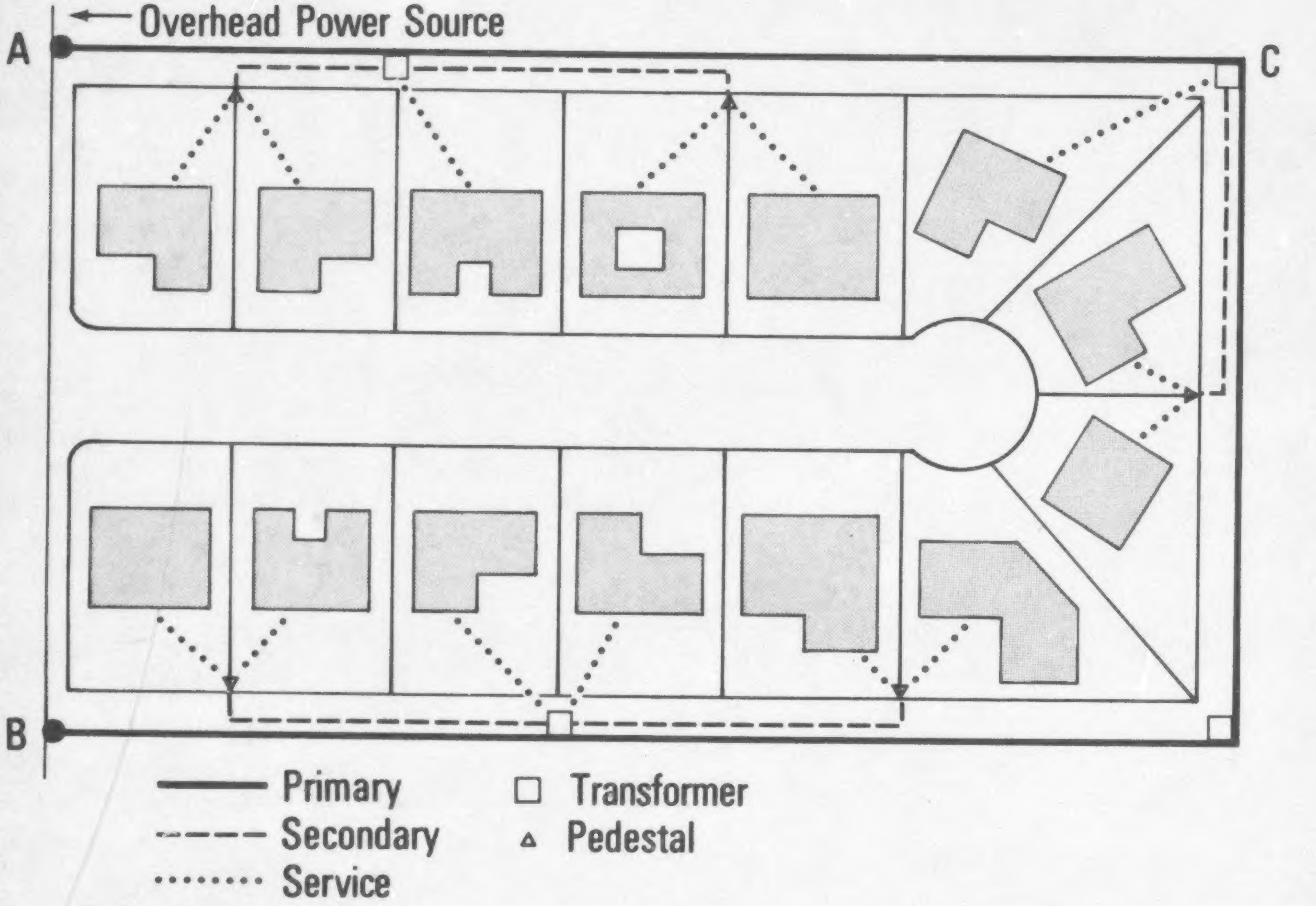
Preformed Slip-On Stress Cones

(Indoor Type)



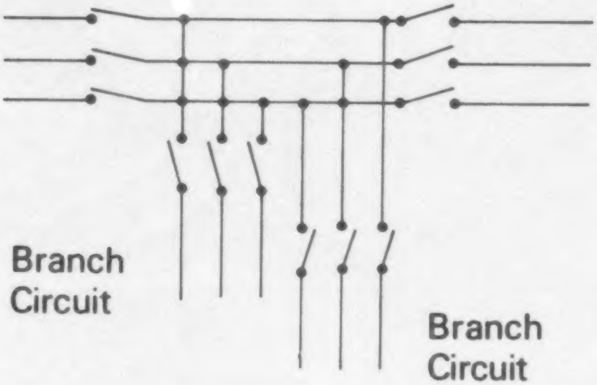


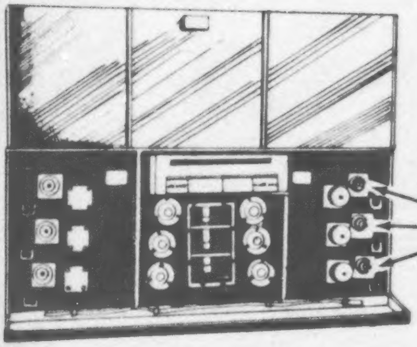
Underground Distribution System



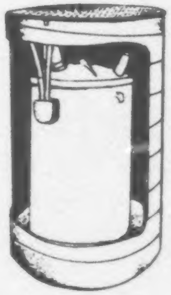
Power may be fed from point "A" or "B" or both. If fed from both points, line will be open at point "C".

Switching Cabinet And Vault





Switching Cabinets Are Constructed For Specific Needs. This Cabinet Shows The Capability Of Two Three-Phase Feeds And Two Three-Phase Branch Circuits.



Cut-Away View Of Fiber Vault Showing Submersible Transformer Installed

UNDERGROUND DISTRIBUTION CONSTRUCTION
UNIT VI

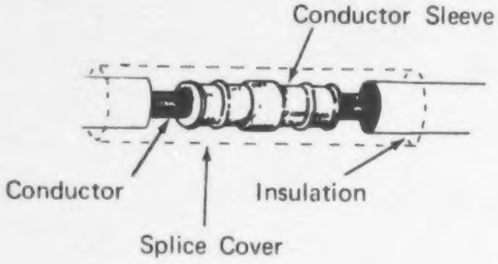
JOB SHEET #1--MAKE A SPLICE IN SECONDARY CABLE

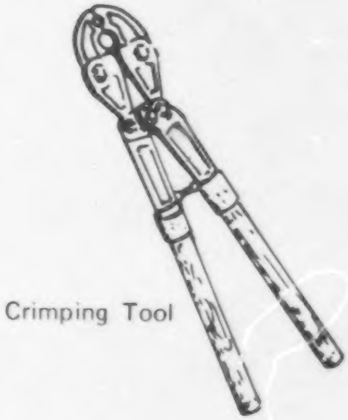
I. Tools and materials (Figure 1)

- A. Rule
- B. Insulation removing tool
- C. Conductor sleeve
- D. Crimping tool
- E. Splice cover

  (NOTE: There are several different types of splice covers which are suitable for secondary splicing.)
- F. Skinning knife
- G. Cable cutter

FIGURE 1





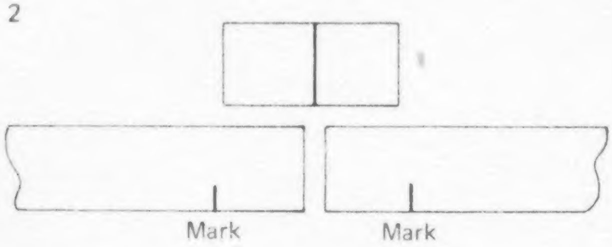
JOB SHEET #1

II. Procedure

A. Gather tools and materials

B. Measure and mark distance from end of conductor that insulation is to be removed for conductor sleeve (Figure 2)

FIGURE 2

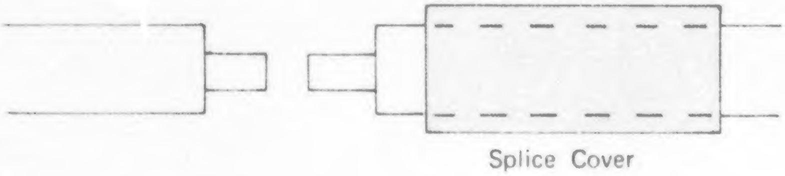


C. Remove insulation to mark (Figure 3)

(NOTE: Care should be taken to avoid damage to conductor when removing insulation.)

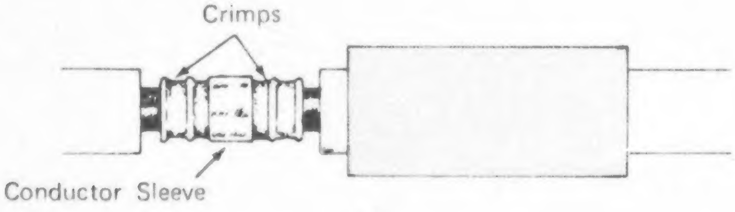
D. Slide splice cover over conductor (Figure 3)

FIGURE 3



E. Install and crimp conductor sleeve (Figure 4)

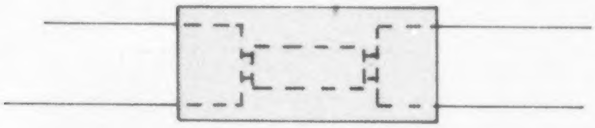
FIGURE 4



JOB SHEET #1

F. Slide splice cover to center of conductor sleeve (Figure 5)

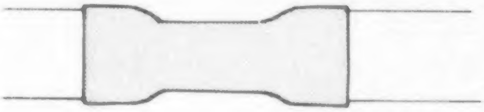
FIGURE 5



G. Apply heat to splice cover to shrink to fit conductor insulation (Figure 6)

(NOTE: Apply epoxy, Scotchkote, or other suitable sealer if a heat-shrink splice cover is not used.)

FIGURE 6



UNDERGROUND DISTRIBUTION CONSTRUCTION
UNIT VI

JOB SHEET #2--MAKE A SPLICE IN PRIMARY CABLE

I. Tools and materials (Figure 1)

   A. Rule

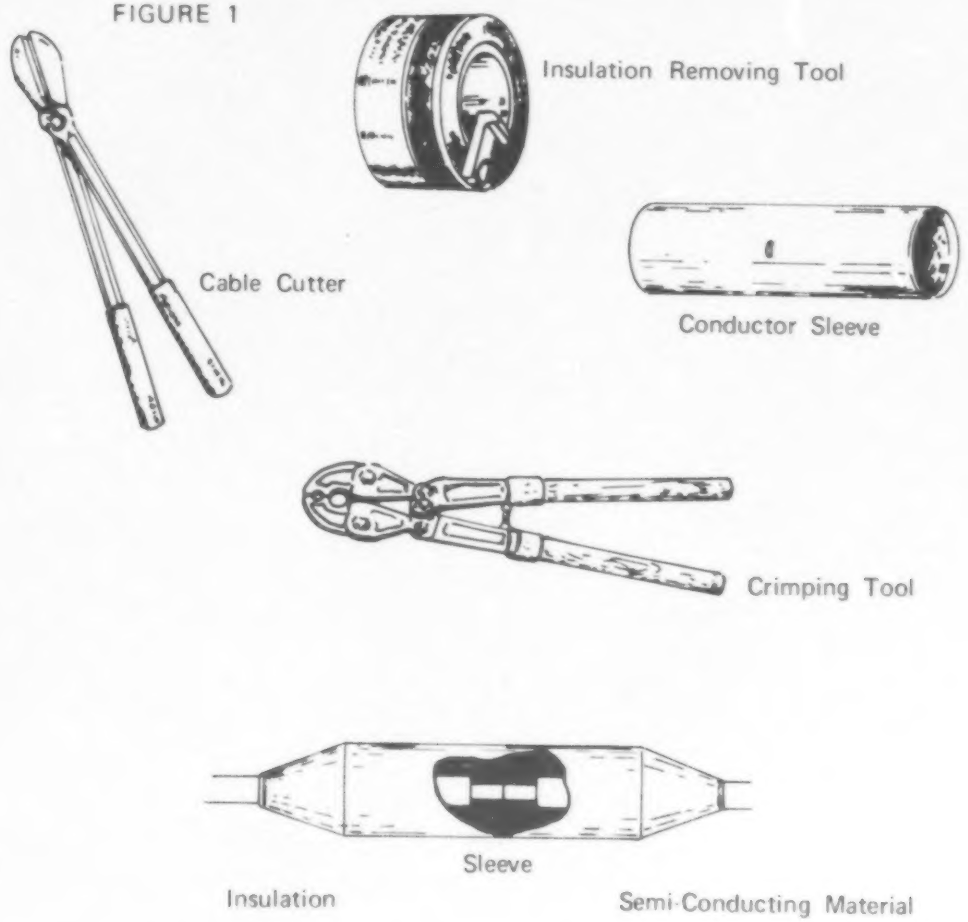
   B. Crimping tool

   C. Insulation removing tool

   D. Cable cutter

   E. Primary cable splice kit

FIGURE 1



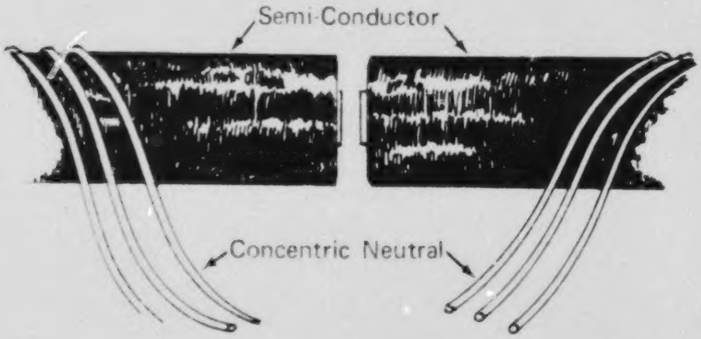
JOB SHEET #2

II. Procedure

A. Remove concentric neutral far enough to install splice (Figure 2)

(NOTE: Do not cut neutral wire.)

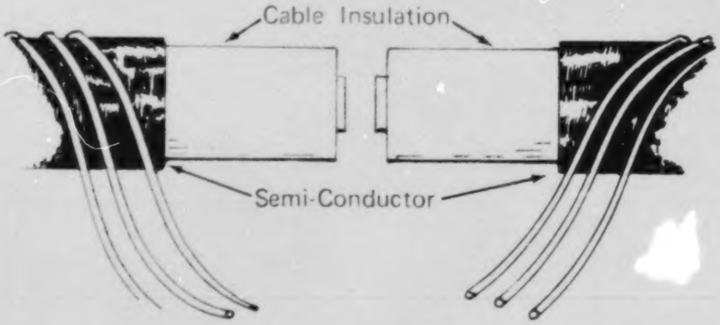
FIGURE 2



B. Remove outer semi-conductor to distance specified by splice manufacturer (Figure 3)

(NOTE: When removing outer semi-conductor, do not cut or nick the insulation.)

FIGURE 3



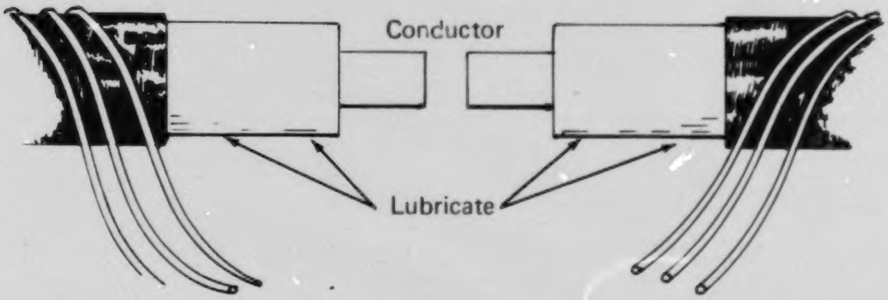
JOB SHEET #2

C. Remove insulation and inner semi-conductor to distance specified by manufacturer (Figure 4)

(NOTE: Do not cut or nick conductor when removing insulation.)

D. Lubricate contact area of cable with silicone grease (Figure 4)

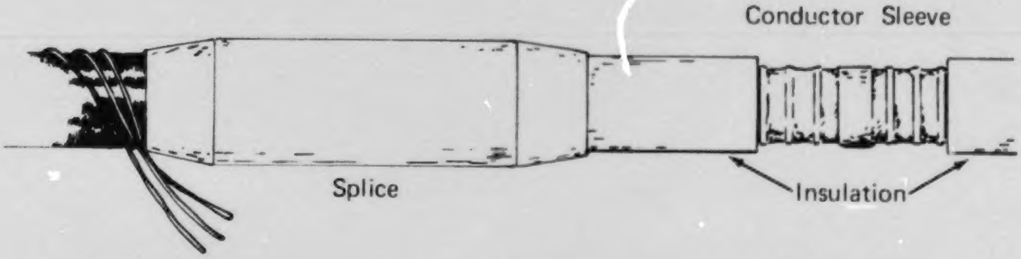
FIGURE 4



E. Slide splice onto cable (Figure 5)

F. Install conductor sleeve and crimp (Figure 5)

FIGURE 5

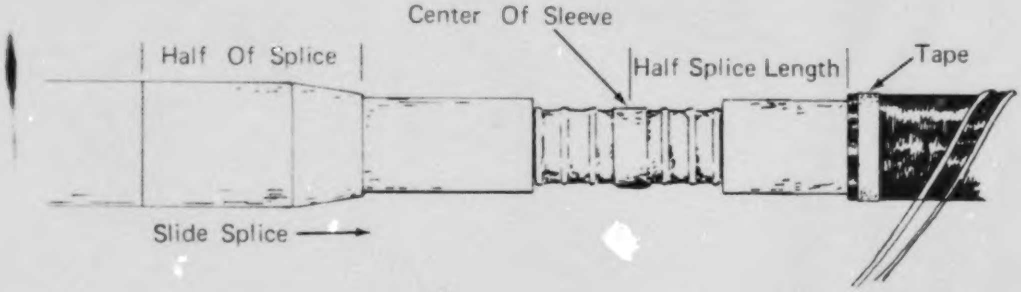


JOB SHEET #2

G. Measure splice from center to end (Figure 6)

H. Measure from center of conductor sleeve to the distance of one-half the splice length; mark cable with tape (Figure 6)

FIGURE 6



I. Slide splice over conductor sleeve until end of splice reaches the tape mark; remove tape (Figure 6)

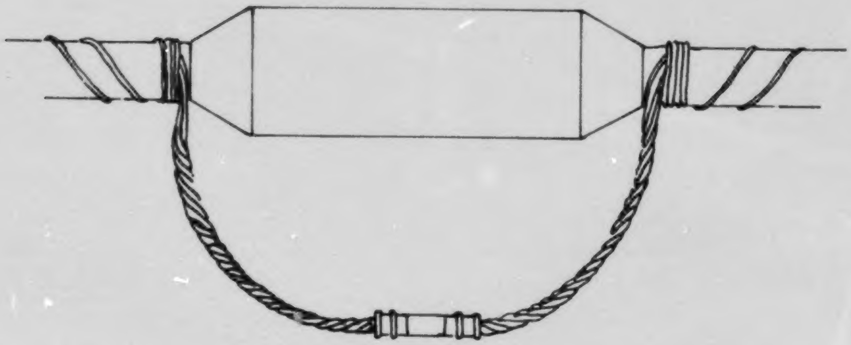
(NOTE: The splice must overlap the outer semi-conductor of the cable at both ends of splice.)

J. Wrap concentric neutral back on cable to within one inch of ends of splice (Figure 7)

JOB SHEET #2

K. Use one strand of concentric neutral to wrap around cable and concentric neutral to bond concentric neutral wires to cable (Figure 7)

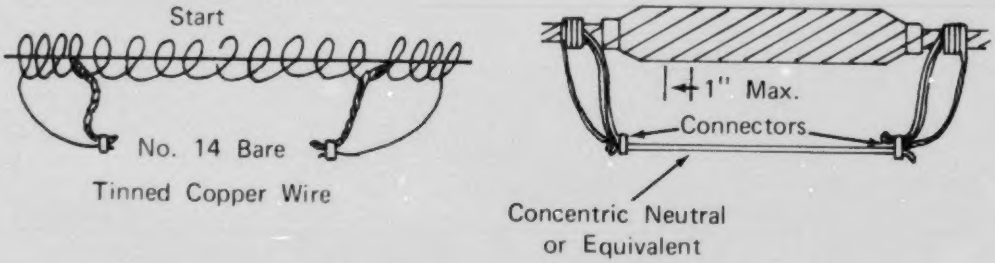
FIGURE 7



L. Twist ends of concentric neutral until entire length of concentric neutral beyond wrap is tightly bound together (Figure 7)

M. Wrap entire splice in one inch or less spirals with #14 gauge bare tinned copper and bond each end of the wrap wire to the concentric neutral (Figure 8)

FIGURE 8



N. Connect ends of concentric neutral together

UNDERGROUND DISTRIBUTION CONSTRUCTION
UNIT VI

TEST

NAME ______________________________ SCORE ____________________

1. Match the terms on the right to the correct definitions. (Definitions are continued on the following page.)

_____a. Length of conduit installed on a pole or a building to protect underground cable above the ground

_____b. Unit installed on the ends of primary cable

_____c. Cone or tape designed to disperse electric flux lines

_____d. Area of housing or business fed by underground power lines

_____e. Electric flux lines which concentrate at the ends of high voltage cable and deteriorate cable insulation

_____f. Solid material that has electrical characteristics between that of a conductor and an insulator and is used for stress control

_____g. Underground cable which runs from transformer or pedestal to metering point

_____h. Conductor spiraled around insulated conductor or conductors in both high and low voltage cable

_____i. High voltage cable which runs from source of power to transformer or protective equipment

_____j. Heavy underground cable which runs from transformer to pedestal

_____k. Buried or partially buried enclosure used as a point of connection for secondary and service cable

1. Service cable
2. Secondary cable
3. Primary cable
4. Pedestal
5. Riser
6. Connector block
7. Terminator
8. Concentric neutral
9. Stress
10. Stress cone
11. Semi-conductor
12. Underground distribution system
13. Feed-through bushing
14. Vault
15. Switching cabinet

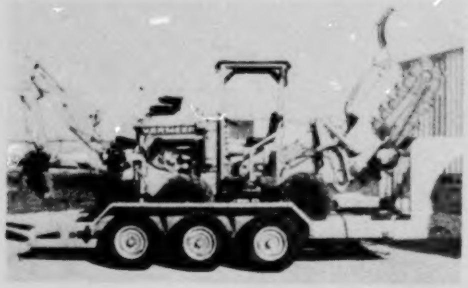
______l. Bushing used on transformers and switching gear for connecting elbow terminators

______m. Metal enclosure which contains equipment for changing circuit feeds or loads from one circuit to another

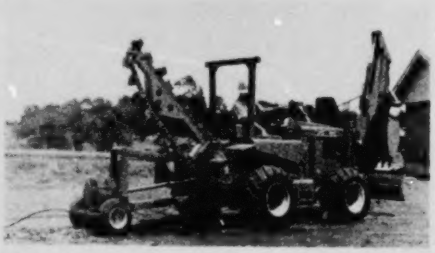
______n. Aluminum or copper block used to connect conductors

______o. Fiber or concrete enclosure installed below grade to house transformer or switching gear

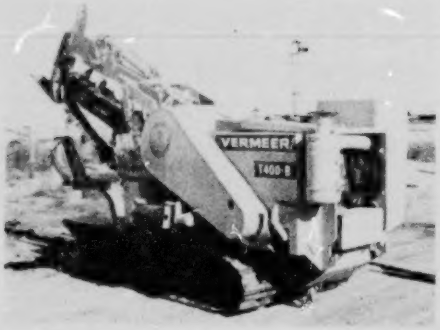
2. Identify the following equipment used in underground construction.



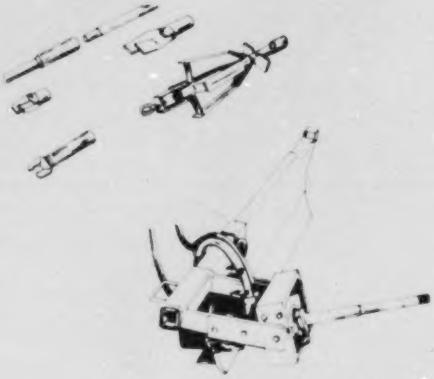
a. ______________________



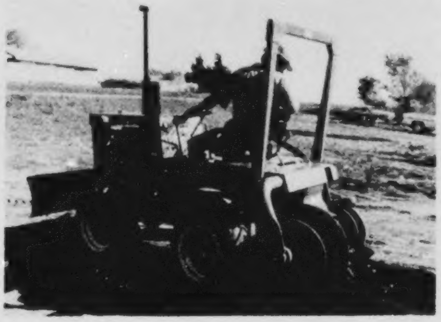
b. ______________________



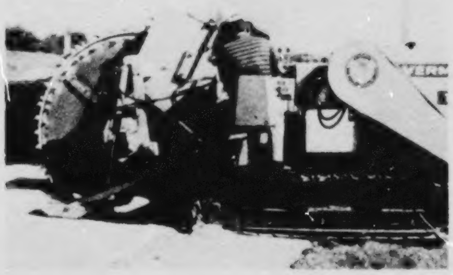
c. ______________________



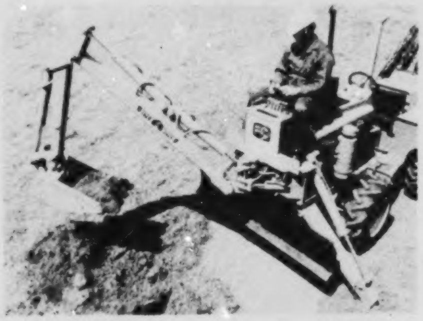
d. ______________________



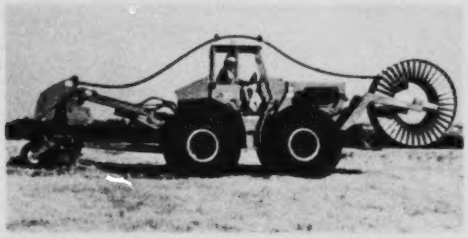
e. ______________________



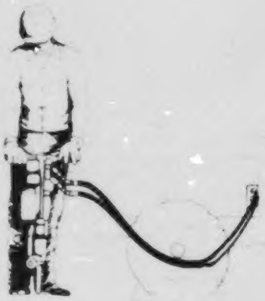
f. ______________________

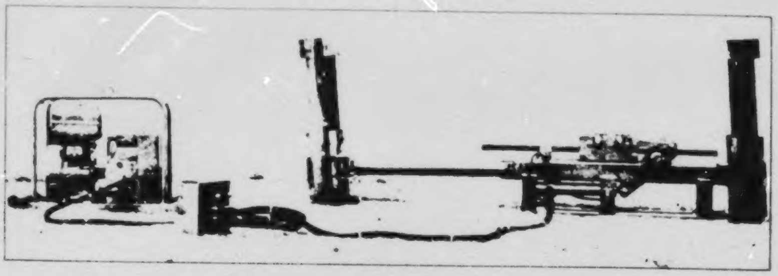


g. ______________________



h. ______________________





i. ______________________ j. ______________________

3. Match the equipment on the right to the correct use.

_____a. Transports equipment to and from job sites

_____b. Pushes large diameter pipe under streets and paved areas

_____c. Plows in cable at great depth in open country where pipelines or other underground utilities are not present

_____d. Trenches in frozen ground and in rocky structures

_____e. Trenches and backfills on short cable runs where great depth is not needed

_____f. Trenches in muddy or sandy areas where long cable runs are needed

_____g. Digs out large areas for working room

_____h. Breaks up concrete or hard rock

_____i. Bores and reams out holes under streets and paved areas

_____j. Plows in cable where great depth is not needed or trenches when greater depth is necessary

1. Hydraulic jackhammer
2. Equipment trailer
3. Large cable plow with cable reel attachment
4. Larger trencher with frost- and rock-cutting teeth
5. Small trencher with backfill blade
6. Backhoe attachment
7. Large track mounted trencher
8. Medium-sized trencher with cable plow
9. Hydraulic pipe pusher
10. Boring machine and boring tools

4. List two general requirements for underground construction.

a. ______________________________

b. ______________________________

5. Arrange in order the correct procedure for installing cable. Place a "1" before the first step, a "2" before the second step, and so on.

_____a. Inspect cable as it is removed from reel

_____b. Backfill

_____c. Remove any objects from trench that might damage cable

_____d. Lay cable in trench by hand

_____e. Lay out cable from moving vehicle

_____f. Lay conduit under streets

6. List three precautions to observe when handling underground cable.

a. ______________________________

b. ______________________________

c. ______________________________

7. Select from the following list methods of marking cable for identification.

_____a. Colored plastic tape

_____b. Paper tags

_____c. Embossed plastic tape

_____d. Corrosion-resistant metal tags

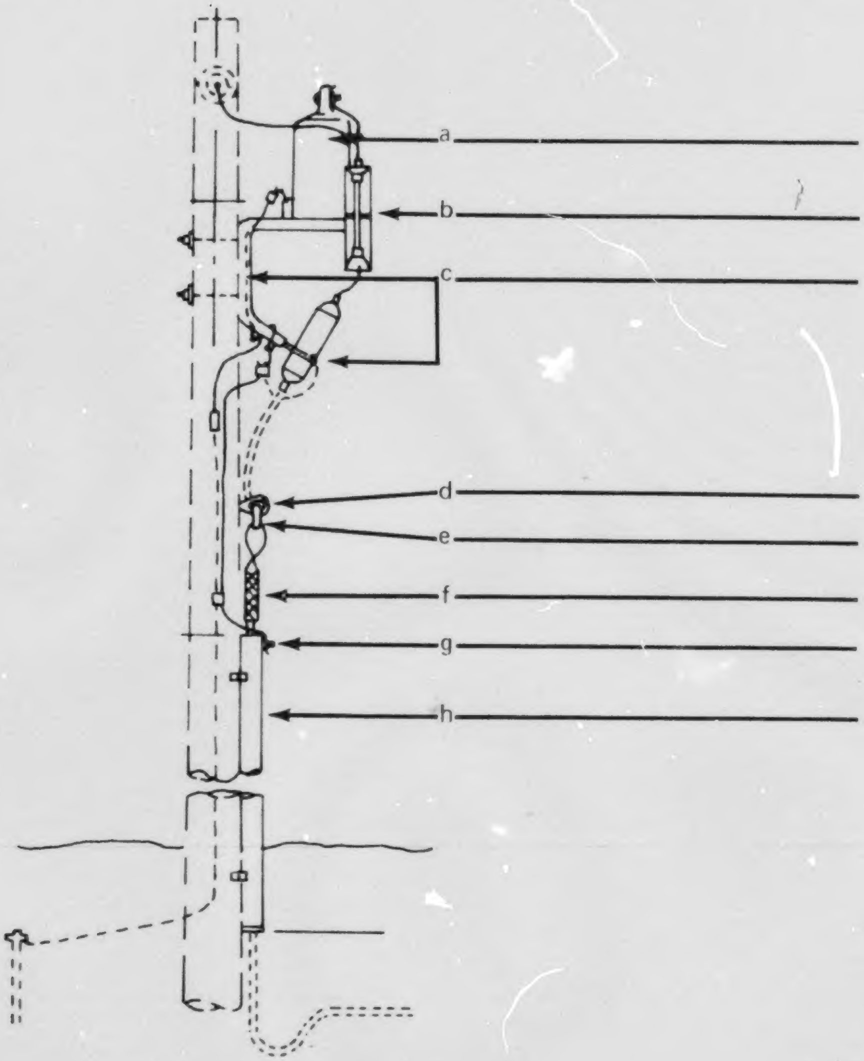
_____e. Imprinted plastic tags

8. List two methods used to locate and identify a utility ditch.

a. ______________________________

b. ______________________________

9. Identify the following equipment used to terminate primary cable on a pole.



10. State the requirement for grounding underground equipment.

____

____

11. List four hazards which may be encountered in underground construction.

a. ____

b. ____

c. ____

d. ____

12 List seven precautions to observe when splicing or terminating cable.

a. ____

b. ____

c. ____

d. ____

e. ____

f. ____

g. ____

13. Select from the list below the tools used in underground construction.

______a. Trench cleaning spoon

______b. Cable cutters

______c. Insulation removing tool

______d. Chain hoist

______e. Hand shovel

______f. Guy grip

______g. Compression tool

14. Demonstrate the ability to:

a. Make a proper splice in secondary cable.

b. Make a proper splice in primary cable.

(NOTE: If the above activities have not been accomplished prior to the test, ask the instructor when they should be completed.)

UNDERGROUND DISTRIBUTION CONSTRUCTION
UNIT VI

ANSWERS TO TEST

1. Match the terms on the right to the correct definitions.

5 a. Length of conduit installed on a pole or a building to protect underground cable above the ground

7 b. Unit installed on the ends of primary cable

10 c. Cone or tape designed to disperse electric flux lines

12 d. Area of housing or business fed by underground power lines

9 e. Electric flux lines which concentrate at the ends of high voltage cable and deteriorate cable insulation

11 f. Solid material that has electrical characteristics between that of a conductor and an insulator and is used for stress control

1 g. Underground cable which runs from transformer or pedestal to metering point

8 h. Conductor spiraled around insulated conductor or conductors in both high and low voltage cable

3 i. High voltage cable which runs from source of power to transformer or protective equipment

2 j. Heavy underground cable which runs from transformer to pedestal

4 k. Buried or partially buried enclosure used as a point of connection for secondary and service cable

1. Service cable
2. Secondary cable
3. Primary cable
4. Pedestal
5. Riser
6. Connector block
7. Terminator
8. Concentric neutral
9. Stress
10. Stress cone
11. Semi-conductor
12. Underground distribution system
13. Feed-through bushing
14. Vault
15. Switching cabinet

_13_ l. Bushing used on transformers and switching gear for connecting elbow terminators

_15_ m. Metal enclosure which contains equipment for changing circuit feeds or loads from one circuit to another

_6_ n. Aluminum or copper block used to connect conductors

_14_ o. Fiber or concrete enclosure installed below grade to house transformer or switching gear

2. Identify the following equipment used in underground construction.

   a. Equipment trailer

   b. Medium-sized trencher with cable plow attached

   c. Large track mounted trencher

   d. Boring machine and boring tools

   e. Small trencher with backfill blade

   f. Large trencher with frost- and rock-cutting teeth

   g. Backhoe attachment

   h. Large cable plow with cable reel attachment

   i. Hydraulic jackhammer

   j. Hydraulic pipe pusher

3. Match the equipment on the right to the correct use.

_2_ a. Transports equipment to and from job sites

_9_ b. Pushes large diameter pipe under streets and paved areas

_3_ c. Plows in cable at great depth in open country where pipelines or other underground utilities are not present

_4_ d. Trenches in frozen ground and in rocky structures

_5_ e. Trenches and backfills on short cable runs where great depth is not needed

1. Hydraulic jackhammer
2. Equipment trailer
3. Large cable plow with cable reel attachment
4. Large trencher with frost- and rock-cutting teeth
5. Small trencher with backfill blade

7 f. Trenches in muddy or sandy areas where long cable runs are needed

6 g. Digs out large areas for working room

1 h. Breaks up concrete or hard rock

10 i. Bores and reams out holes under streets and paved areas

8 j. Plows in cable where great depth is not needed or trenches when greater depth is necessary

6. Backhoe attachment

7. Large track mounted trencher

8. Medium-sized trencher with cable plow

9. Hydraulic pipe pusher

10. Boring machine and boring tools

4. List two general requirements for underground construction.

(NOTE: Any two of the following are acceptable.)

a. All work should be done in a thorough and skillful manner

b. All work should be done in accordance with plans and specifications

c. All work should meet or exceed the National Electrical Safety Code requirements

5. Arrange in order the correct procedure for installing cable. Place a "1" before the first step, a "2" before the second step, and so on.

3 a. Inspect cable as it is removed from reel

6 b. Backfill

4 c. Remove any objects from trench that might damage cable

5 d. Lay cable in trench by hand

2 e. Lay out cable from moving vehicle

1 f. Lay conduit under streets

6. List three precautions to observe when handling underground cable.

(NOTE: Any three of the following are acceptable.)

a. Handle carefully to avoid damage

b. Avoid excessive bending

c. Keep ends of cable sealed against moisture

d. Do not drag cable

7. Select from the following list methods of marking cable for identification.

__X__ a. Colored plastic tape

_____ b. Paper tags

__X__ c. Embossed plastic tape

__X__ d. Corrosion resistant metal tags

__X__ e. Imprinted plastic tags

8. List two methods used to locate and identify a utility ditch.

(NOTE: Any two of the following are acceptable.)

a. Above grade stake driven near ditch with name of utility attached

b. Plate inscribed with utility name placed over cable and flush with ground

c. Electronic voltage detector if cable is energized

d. Plastic tape inscribed with Caution: Electric Power Cable Below buried near surface of ditch

9. Identify the following equipment used to terminate primary cable on a pole.

a. Lightning arrester

b. Fuse cut-out

c. Terminator and bracket

d. Eye bolt

e. Shackle

f. Wire sock

g. Grounding bushing

h. Riser

10. State the requirement for grounding underground equipment.

All neutral conductors and groundable parts shall be interconnected

11. List four hazards which may be encountered in underground construction.

    a. Loop feed system

    b. Equipment that has not been properly grounded

    c. Regenerated charge that can exist on high voltage ungrounded cable

    d. Other utilities

12. List seven precautions to observe when splicing or terminating cable.

    a. Ground the cable being repaired

    b. Use portable cover or shelter

    c. Keep material and cable dry

    d. Keep hands, material, and cable clean

    e. Clean surfaces with denatured alcohol

    f. Lubricate contacting surfaces with silicone grease

    g. Follow manufacturer's specifications

13. Select from the list below the tools used in underground construction.

    ___X___ a. Trench cleaning spoon

    ___X___ b. Cable cutters

    ___X___ c. Insulation removing tool

    _______ d. Chain hoist

    ___X___ e. Hand shovel

    _______ f. Guy grip

    ___X___ g. Compression tool

14. Demonstrate the ability to:

    a. Make a proper splice in secondary cable.

    b. Make a proper splice in primary cable.

    (NOTE: Performance skills should be evaluated to the satisfaction of the instructor.)

PERSONAL CLIMBING TOOLS AND EQUIPMENT
UNIT VII

UNIT OBJECTIVE

After completion of this unit, the student should be able to identify personal climbing tools and equipment and list inspection and maintenance procedures. The student should be able to list safety precautions to observe when climbing poles and demonstrate the ability to climb poles safely. This knowledge will be evidenced through demonstration and by scoring 100 percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms associated to personal climbing tools and equipment to the correct definitions.
2. Identify personal climbing tools and equipment.
3. Match tools and equipment to the specific use.
4. List conditions to watch for when inspecting personal climbing tools and equipment.
5. Name types of maintenance for personal climbing tools and equipment.
6. List safety precautions to observe when climbing poles.
7. Select from a list the general procedure for climbing poles.
8. Name rules for safe and proper storage of personal tools and equipment.
9. Demonstrate the ability to climb poles.

PERSONAL CLIMBING TOOLS AND EQUIPMENT
UNIT VII

SUGGESTED ACTIVITIES

I. Suggested activities for the instructor:

   A. Provide student with objective sheet.

   B. Provide student with information and job sheets.

   C. Make transparency.

   D. Discuss unit and specific objectives.

   E. Discuss information sheet.

   F. Demonstrate and discuss procedure outlined in the job sheet.

   G. Give test.

II. Unit reference--Kurtz, Edwin B., and Shoemaker, Thomas M. *The Lineman's and Cableman's Handbook.* 5th ed. New York: McGraw-Hill Book Co., 1976.

PERSONAL CLIMBING TOOLS AND EQUIPMENT
UNIT VII

INFORMATION SHEET

I. Terms and definitions

A. Body belt--Belt which is fitted to hip measurement and used to carry hand tools while working on above-ground structures

B. Safety strap--Strap used to secure a line technician working on a structure

C. Climber--L-shaped steel or aluminum strap used to climb wood structures

D. Strap--Leather or nylon band with attached buckle used to secure climber to line technician's leg

E. Pad--Leather or nylon cushion used to protect line technician's leg

F. Gaff--Metal spur attached to the inside of climber

G. D-ring--Tested metal ring attached to either end of body belt

H. Snap--Tested metal hook with a spring-loaded safety catch which is attached to either end of safety strap

I. Gaff gauge--Measuring tool used to determine correct length, width, thickness, and shape of gaff

II. Personal climbing tools and equipment (Transparency 1)

(NOTE: Use only approved tools.)

A. Climbers

B. Pads

C. Strap

D. Safety strap

E. Body belt with D-rings

F. Gaff gauge

III. Tool and equipment use

A. Climbers, straps, and pads

1. Assist line technician in climbing wood structure

2. Assist line technician to maintain position on wood structure

INFORMATION SHEET

- B. Body belt
  - 1. Holds tools
  - 2. Holds line technician while working on structure
- C. Safety strap--Supports weight of line technician and equipment

IV. Inspection of tools and equipment

- A. Body belt

  (CAUTION: Wire hooks or metal straps shall not be attached to body belt.)

  - 1. Loose stitching
  - 2. Loose rivets
  - 3. Cracks in leather
  - 4. Hard or brittle spots in leather
  - 5. Cuts or tears in leather
- B. Safety strap

  (NOTE: If safety strap is worn to unsafe conditions, it should be destroyed.)

  - 1. Worn spots
  - 2. Enlarged buckle holes
  - 3. Cuts or tears
  - 4. Distorted snaps
  - 5. Crack in snaps
  - 6. Weak springs in snaps
  - 7. Loose rivets
  - 8. Stitching
- C. Climber
  - 1. Worn straps
  - 2. Crack in metal
  - 3. Worn area of footpiece

INFORMATION SHEET

D. Gaff

(NOTE: Only proper replacement part may be used.)

1. Length
2. Width
3. Thickness
4. Shape

V. Maintenance of tools and equipment

A. Body belt and leather equipment

1. Clean leather with natural soap (castile)
2. Dress leather with saddle soap and a good leather dressing

B. Gaff

1. Check with gaff gauge frequently
2. File underside and sides to shape and sharpen

(NOTE: The center line of the outside of the gaff should not be filed, it must retain its original straight-line shape.)

VI. Safety precautions to observe when climbing poles

A. Avoid cracks, knots, and bird holes

B. Avoid wires, steeples, and hardware

C. Avoid using braces or hardware to climb

D. Set both climbers securely when safetying off

E. Check safety snap visually to see that it is secured in D-ring

F. Do not safety off above top crossarm on distribution line

G. Do not safety off on pole-top pins or other hardware

H. Do not snap both ends of safety strap in one D-ring when safetying off on a structure

(NOTE: Use your climbing tools only in the manner that they were intended to be used.)

INFORMATION SHEET

VII. General procedure for climbing poles

- A. Inspect pole for unsafe conditions

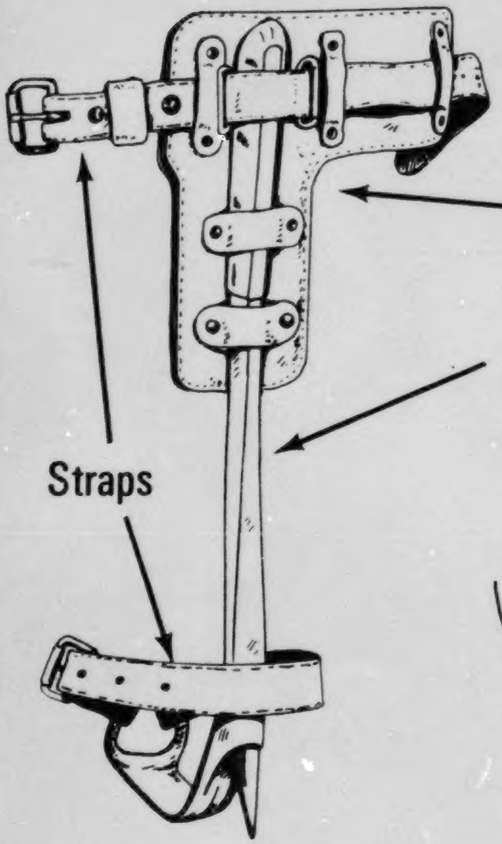
  (NOTE: Unsafe conditions include nails, pole steps, clotheslines, or other unauthorized attachments.)

- B. Remove rocks and other objects from base of pole
- C. Wear gloves and long sleeves for protection of hands and arms
- D. Step onto pole with gaff point directed toward center of pole
- E. Keep knees, hips, and shoulders away from pole
- F. Take short steps (6 to 8 inches)
- G. Remove gaff from pole by swinging knee away from pole with a breaking away motion
- H. Use hands and arms for balance only
- I. Climb with the legs
- J. Wear body belt and safety strap when climbing
- K. Take hand line up pole

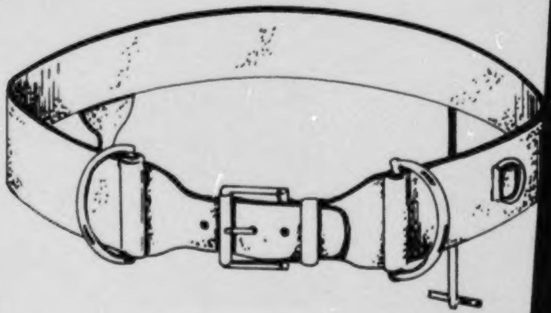
VIII. Rules for safe and proper storage of personal climbing tools and equipment

- A. Leather goods
  - 1. Store away from heat source
  - 2. Do not store with sharp-edged objects
  - 3. Store in proper area
- B. Climbers--Store with gaff guards on gaffs

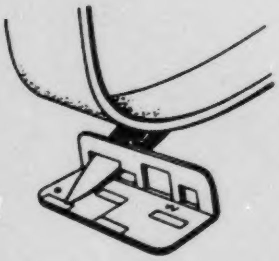
Personal Climbing Tools and Equipment



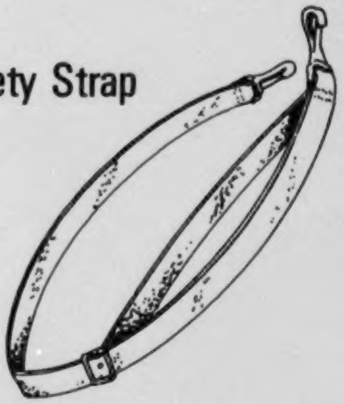
Body Belt With D-Rings



Gaff Gauge



Safety Strap



PERSONAL CLIMBING TOOLS AND EQUIPMENT
UNIT VII

JOB SHEET #1--CLIMB POLES

I. Tools, equipment, and materials

  A. Climbers

  B. Body belt

  C. Safety strap

  D. Gloves

  E. Hard hat

  F. Long-sleeved shirt

  G. Hand line

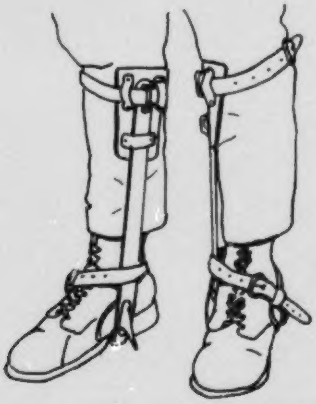
  H. Pole, 10 to 12 inches in diameter and 12 feet tall

II. Procedure for climbing

  A. Prepare to climb

    1. Place climbers on legs, snug but not tight (Figure 1)

FIGURE 1



2

JOB SHEET #1

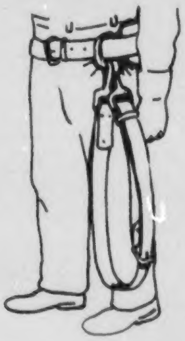
2. Place body belt just below waist, snug but not tight (Figure 2)

3. Place both ends of safety strap in left D-ring

    a. Place double end of strap next to body with opening side of snap facing outward

    b. Place single end of strap with opening side of snap facing inward (Figure 2)

FIGURE 2

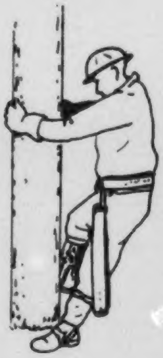


(NOTE: Do not let end of safety strap swing free when climbing or descending pole or when changing positions.)

B. Ascend pole

1. Stand facing pole with knees, hips, and shoulders a comfortable distance from pole (Figure 3)

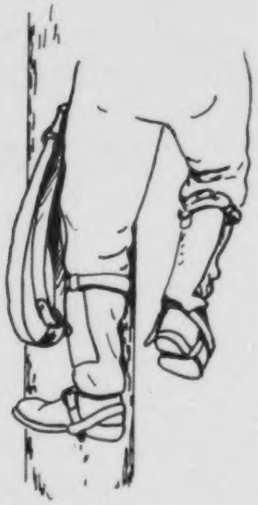
FIGURE 3



JOB SHEET #1

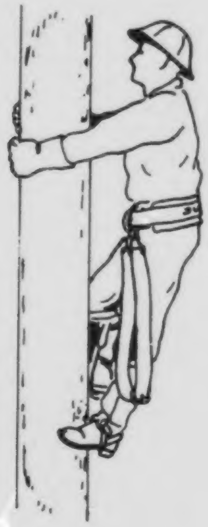
2. Direct gaff point of right climber toward center of pole and place gaff in pole (Figure 4)

FIGURE 4



3. Ascend pole to 3 feet in short steps, keeping knees, hips, and shoulders away from pole (Figure 5)

FIGURE 5



(NOTE: Use legs to climb and hands and arms for balance.)

4. Place both gaffs firmly in pole

JOB SHEET #1

5. Remove single end of safety strap with left hand and place around back side of pole (Figures 6 and 7)

FIGURE 6

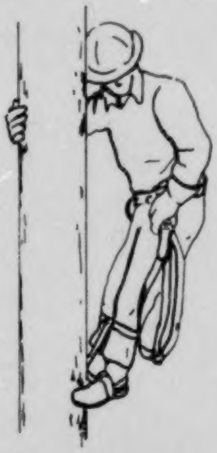
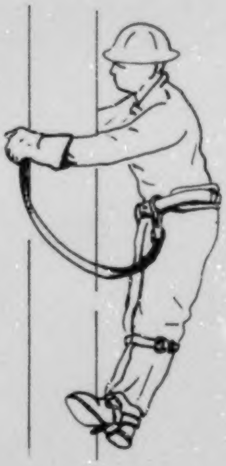
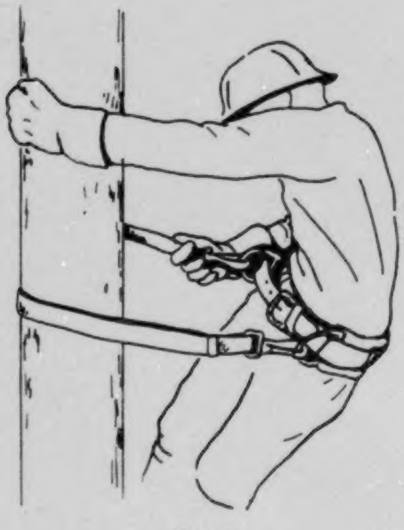


FIGURE 7



6. Take single end of safety strap in right hand and snap into right D-ring with opening side of snap facing outward; check snap visually (Figure 8)

FIGURE 8



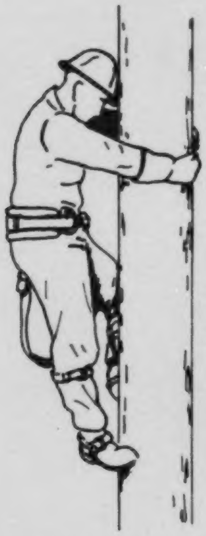
JOB SHEET #1

C. Descend pole

1. Disconnect safety strap from right D-ring and connect to left D-ring with opening side of snap facing inward

2. Remove left climber from pole by swinging knee away from pole with a breaking away motion (Figure 9)

FIGURE 9



3. Descend pole by lowering left foot and left hand at the same time and right hand and right foot at the same time

PERSONAL CLIMBING TOOLS AND EQUIPMENT
UNIT VII

TEST

NAME ______________________________ SCORE ____________________

1. Match the terms on the right to the correct definitions.

_____a. Belt which is fitted to hip measurement and used to carry hand tools while working on above-ground structures

_____b. Strap used to secure a line technician while working on a structure

_____c. L-shaped steel or aluminum strap used to climb wood structures

_____d. Leather or nylon band with attached buckle used to secure climber to line technician's leg

_____e. Leather or nylon cushion used to protect line technician's leg

_____f. Metal spur attached to the inside of climber

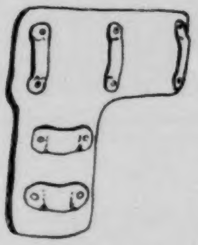
_____g. Tested metal ring attached to either end of body belt

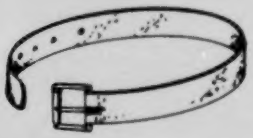
_____h. Tested metal hook with a spring-loaded safety catch which is attached to either end of safety strap

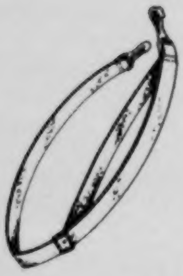
_____i. Measuring tool used to determine correct length, width, thickness, and shape of gaff

1. D-ring
2. Strap
3. Pad
4. Body belt
5. Gaff gauge
6. Gaff
7. Snap
8. Safety strap
9. Climber

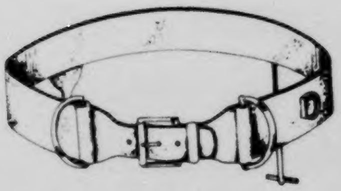
2. Identify the following personal climbing tools and equipment.

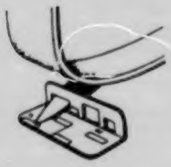


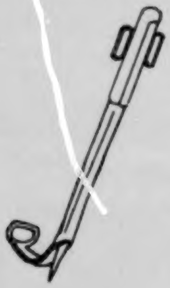




a. ________________ b. ________________ c. ____________







d. ________________ e. ________________ f. ____________

3. Match the tools and equipment on the right to the specific use.

_____a. Assists line technician in climbing wood structure; assists line technician to maintain position on wood structure	1. Safety strap
_____b. Holds tools; holds line technician while working on a structure	2. Body belt
_____c. Supports weight of line technician and equipment	3. Climbers, straps, and pads

4. List two conditions to watch for when inspecting each of the following personal climbing tools and equipment.

a. Body belt

1) ____

2) ____

b. Safety strap

1) ____

2) ____

c. Climber

1) ________________________________

2) ________________________________

d. Gaff

1) ________________________________

2) ________________________________

5. Name two items of maintenance for each of the following types of tools and equipment.

a. Body belt and leather equipment

1) ________________________________

2) ________________________________

b. Gaff

1) ________________________________

2) ________________________________

6. List five safety precautions to observe when climbing poles.

a. ________________________________

b. ________________________________

c. ________________________________

d. ________________________________

e. ________________________________

7. Select from the following list those statements which are part of the general procedure for climbing poles. Place an "X" in the blanks provided.

_____a. Inspect pole for unsafe conditions

_____b. Remove rocks and other objects from base of pole

_____c. Wear gloves and long sleeves for protection of hands and arms

_____d. Step onto pole with gaff point directed toward center of pole ______e. Wear thin-soled shoes to feel position of climbers

______f. Keep knees, hips, and shoulders away from pole

______g. Take short steps (6 to 8 inches)

______h. Remove gaff from pole by swinging knee away from pole with a breaking away motion

______i. Use hands and arms for balance only

______j. Climb with the legs

______k. Wear body belt and safety strap when climbing

______l. Take hand line up pole

8. Name three rules for storage of leather goods and one rule for storage of climbers.

a. Leather goods

1) ____

2) ____

3) ____

b. Climbers--____

9. Demonstrate the ability to climb poles.

(NOTE: If this activity has not been accomplished prior to the te[illegible], ask the instructor when it should be completed.)

PERSONAL CLIMBING TOOLS AND EQUIPMENT
UNIT VII

ANSWERS TO TEST

1. Match the terms on the right to the correct definitions.

__4__ a. Belt which is fitted to hip measurement and used to carry hand tools while working on above-ground structures

__8__ b. Strap used to secure a line technician while working on a structure

__9__ c. L-shaped steel or aluminum strap used to climb wood structures

__2__ d. Leather or nylon band with attached buckle used to secure climber to line technician's leg

__3__ e. Leather or nylon cushion used to protect line technician's leg

__6__ f. Metal spur attached to the inside of climber

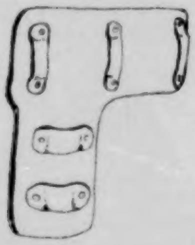
__1__ g. Tested metal ring attached to either end of body belt

__7__ h. Tested metal hook with a spring-loaded safety catch which is attached to either end of safety strap

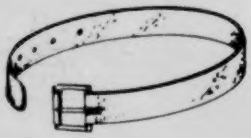
__5__ i. Measuring tool used to determine correct length, width, thickness, and shape of gaff

1. D-ring
2. Strap
3. Pad
4. Body belt
5. Gaff gauge
6. Gaff
7. Snap
8. Safety strap
9. Climber

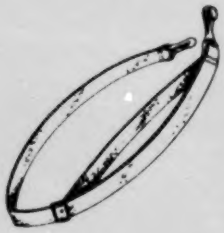
2. Identify the following personal climbing tools and equipment.



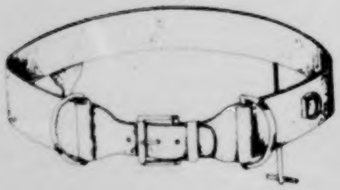
a. Pad



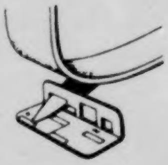
b. Strap



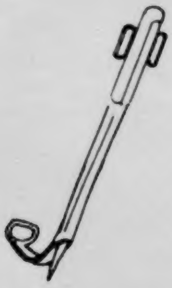
c. Safety strap



d. Body belt with D-rings



e. Gaff gauge



f. Climber

3. Match the tools and equipment on the right to the specific use.

__3__ a. Assists line technician in climbing wood structure; assists line technician to maintain position on wood structure

__2__ b. Holds tools; holds line technician while working on a structure

__1__ c. Supports weight of line technician and equipment

1. Safety strap
2. Body belt
3. Climbers, straps, and pads

4. List two conditions to watch for when inspecting each of the following personal climbing tools and equipment.

(NOTE: Any two of the following under each category are acceptable.)

a. Body belt

1) Loose stitching
2) Loose rivets
3) Cracks in leather
4) Hard or brittle spots in leather
5) Cuts or tears in leather

- b. Safety strap
  - 1) Worn spots
  - 2) Enlarged buckle holes
  - 3) Cuts or tears
  - 4) Distorted snaps
  - 5) Crack in snaps
  - 6) Weak springs in snaps
  - 7) Loose rivets
  - 8) Stitching
- c. Climber
  - 1) Worn straps
  - 2) Crack in metal
  - 3) Worn area of footpiece
- d. Gaff
  - 1) Length
  - 2) Width
  - 3) Thickness
  - 4) Shape

5. Name two items of maintenance for each of the following types of tools and equipment.

- a. Body belt and leather equipment
  - 1) Clean leather with natural soap (castile)
  - 2) Dress leather with saddle soap and a good leather dressing
- b. Gaff
  - 1) Check with gaff gauge frequently
  - 2) File underside and sides to shape and sharpen

6. List five safety precautions to observe when climbing poles.

(NOTE: Any five of the following are acceptable.)

- a. Avoid cracks, knots, and bird holes
- b. Avoid wires, steeples, and hardware

c. Avoid using braces or hardware to climb

d. Set both climbers securely when safetying off

e. Check safety snap visually to see that it is secured in D-ring

f. Do not safety off above top crossarm on distribution line

g. Do not safety off on pole-top pins or other hardware

n. Do not snap both ends of safety strap in one D-ring when safetying off on a structure

7. Select from the following list those statements which are part of the general procedure for climbing poles. Place an "X" in the blanks provided.

__X__ a. Inspect pole for unsafe conditions

__X__ b. Remove rocks and other objects from base of pole

__X__ c. Wear gloves and long sleeves for protection of hands and arms

__X__ d. Step onto pole with gaff point directed toward center of pole

_____ e. Wear thin-soled shoes to feel position of climbers

__X__ f. Keep knees, hips, and shoulders away from pole

__X__ g. Take short steps (6 to 8 inches)

__X__ h. Remove gaff from pole by swinging knee away from pole with a breaking away motion

__X__ i. Use hands and arms for balance only

__X__ j. Climb with the legs

__X__ k. Wear body belt and safety strap when climbing

__X__ l. Take hand line up pole

8. Name three rules for storage of leather goods and one rule for storage of climbers.

a. Leather goods

1) Store away from heat source

2) Do not store with sharp-edged objects

3) Store in proper area

b. Climbers--Store with gaff guards on gaffs

9. Demonstrate the ability to climb poles.

(NOTE: The performance skills should be evaluated to the satisfaction of the instructor.)

RIGHT-OF-WAY
UNIT VIII

UNIT OBJECTIVE

After completion of this unit, the student should be able to identify tools used for right-of-way clearing and control. The student should be able to trim a tree, remove a limb hanging over an energized conductor, and fell a tree. This knowledge will be evidenced through demonstration and by scoring 100 percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms associated with right-of-way clearing and control to the correct definitions.
2. List methods to maintain good public relations.
3. Identify tools used for right-of-way clearing and control.
4. State the purposes of right-of-way control.
5. Select from a list the safe working procedures for right-of-way clearing and control.
6. Select proper methods of tree trimming.
7. List steps to remove limb hanging over an energized conductor.
8. List steps to fell a tree.
9. State the specifications for clearing right-of-way for distribution line.
10. List types of clearing and chemical control for right-of-way.
11. Identify various trees that grow rapidly.

RIGHT-OF-WAY
UNIT VIII

SUGGESTED ACTIVITIES

I. Suggested activities for instructor:

   A. Provide student with objective sheet.

   B. Provide student with information and assignment sheets.

   C. Discuss unit and specific objectives.

   D. Discuss information and assignment sheets.

   E. Give test.

II. Unit references:

   A. Kurtz, Edwin B., and Shoemaker, Thomas M. *The Lineman's and Cableman's Handbook.* 5th ed. New York: McGraw-Hill Book Co., 1976.

   B. Rural Electrification Administration. *Specifications and Drawings for 14.4/24.9 Kv. Line Construction.* REA Form 803. rev. Washington, D.C.: U. S. Department of Agriculture, 1969.

   C. Rural Electrification Administration. *Brush Control Practices for Right-of-Way Maintenance.* REA Bulletin 161-17. Washington, D.C.: U. S. Department of Agriculture, 1959.

RIGHT-OF-WAY
UNIT VIII

INFORMATION SHEET

I. Terms and definitions

   A. Right-of-way--Area on which permission has been obtained to construct power lines

   B. Clearing--Removal of trees and shrubs from right-of-way

   C. Control--Restrict or remove new growth from right-of-way

   D. Clearance--Recommended distance which should be maintained between conductors and growth

   E. Safety sling--Rope used to secure climber to tree while removing limbs

   F. Underbrush--Shrubs, bushes, or small trees growing beneath large trees

   G. Outage--Interruption of electric service

   H. Power loss--Current not metered or sold to the consumers

II. Methods to maintain good public relations

   A. Obtain permission

   (NOTE: No trimming or clearing should be done before written permission is obtained from property owner.)

   B. Be sure owner understands what work is to be done

   C. Dispose of brush by burning, chipping, or hauling away according to landowner's wishes

   (NOTE: Brush may be placed in nearby washes or ditches to aid in preventing erosion.)

   D. Respect owner's property rights

   (NOTE: Do not leave gates open or damage lawns or shrubs with equipment. Clean area thoroughly before leaving.)

INFORMATION SHEET

III. Tools and equipment used for right-of-way clearing and control (Transparency 1)

(NOTE: In addition to the following tools, the trimmer will need a one-half inch thick polyester rope and spray or brush type tree wound paint.)

A. Power saw

B. Hand saw

C. Long-handled trimmer

D. Pruner

E. Axe

F. Climber's saddle

G. Chipper

(NOTE: Brush chips are thrown from chute on chipper into a truck.)

H. Sprayer

IV. Purposes of right-of-way control

A. Prevent electric service outages

B. Prevent damage to conductors

C. Reduce power loss

(NOTE: Power loss can be substantial if trees or shrubs are allowed to grow into energized conductors.)

D. Allow access to electrical system

V. Safe working procedures

A. Post Men Working signs when working near streets or highways

B. Rope off or barricade area to protect the public

C. Park vehicles a safe distance from work area

D. Check condition of all tools before use

INFORMATION SHEET

- E. Check for overhead power lines
- F. Climb into tree with a ladder

  (NOTE: Tree climbing tools should not be used on a tree that is not going to be removed.)
- G. Use safety sling while trimming tree (Transparency 2)
- H. Use power saw below shoulder level only
- I. Do not use power saw while working in a tree
- J. Keep a separation of at least 10 feet between persons cutting brush
- K. Use axes and hatchets for ground level work only
- L. Wear eye protection
- M. Wear rubber gloves with protectors when working near energized conductors

VI. Methods of tree trimming (Transparencies 3 and 4, Assignment Sheet #1)

- A. Start first cut on bottom side of limb
- B. Start second cut on top side of limb

  (NOTE: Small branches may be removed with only two cuts. Four cuts are necessary to remove large side limbs.)
- C. Slope cut on vertical limbs for good drainage
- D. Remove limb flush with trunk

VII. Steps to remove limb hanging over energized conductor (Transparency 5, Assignment Sheet #2)

- A. Tie butt rope to limb near cut
- B. Tie fall rope near outer end of limb
- C. Tie guide rope at outer end of limb
- D. Extend butt and fall ropes upward and through separate forks in limbs above limb to be removed
- E. Extend guide rope to ground

INFORMATION SHEET

F. Tie butt and fall ropes to tree trunk

G. Secure climber with safety rope

H. Cut limb and swing it away from conductor with guide rope

I. Lower limb with butt and fall rope

VIII. Tree felling (Transparency 6, Assignment Sheet #3)

A. Saw or chop a V-shaped notch 1/4 way through trunk on the side which the tree should fall

B. Saw through tree from opposite side of notch

C. Use rope to guide tree in direction needed

IX. Specifications for clearing right-of-way for distribution line (Transparency 7)

A. Center of pole line to growth--10 feet

B. Total width of clearing--20 feet

C. Minimum distance between conductors and growth--6 feet (Transparency 4)

(NOTE: Right-of-way for transmission line will vary in width according to type of structure used.)

X. Types of right-of-way control according to methods

A. Clearing

1. Hand-operated equipment
2. Motorized equipment

B. Chemical

1. Hand sprayer
2. Aerial spraying
3. Pellet application

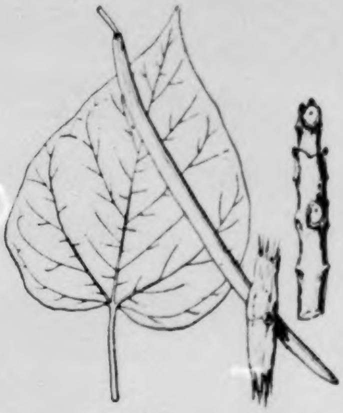
(NOTE: Chemicals used for brush control will kill all woody-stemmed plants. Care should be taken not to spray when wind will blow chemicals into cotton fields or on other broadleaf or woody-stemmed plants.)

INFORMATION SHEET

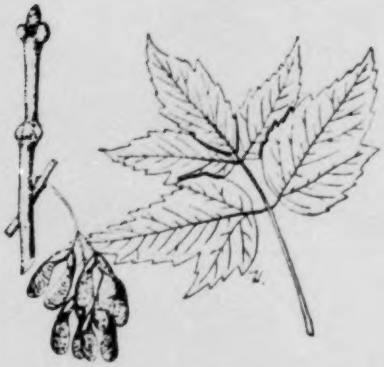
XI. Rapid-growing trees

(NOTE: The following trees grow more rapidly than most trees and should be cut back as much as the owner will allow to prevent annual trimming.)

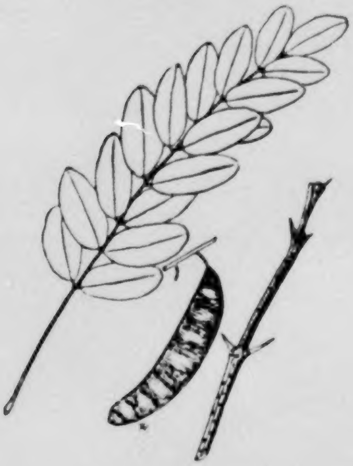
A. Catalpa



B. Box elder

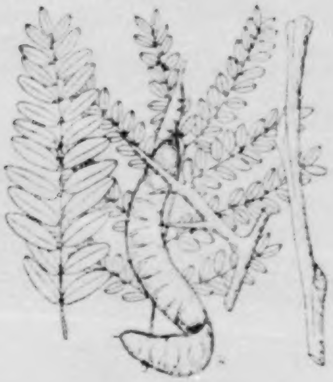


C. Black locust

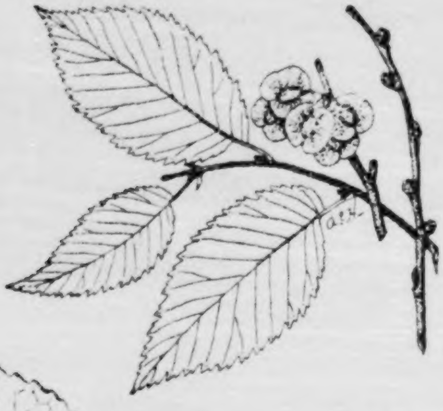


INFORMATION SHEET

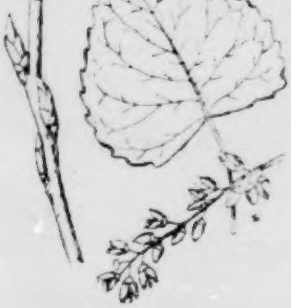
D. Honey locust



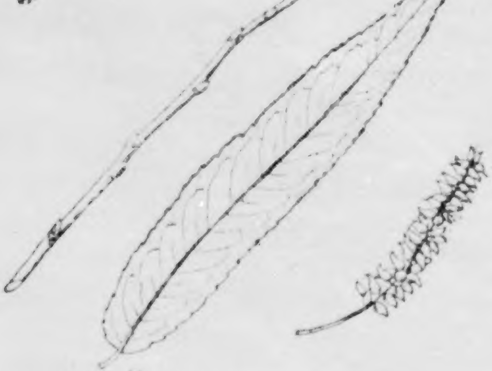
E. Chinese elm



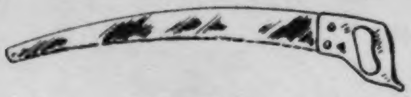
F. Cottonwood



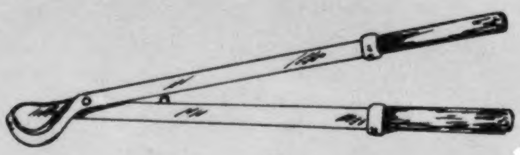
G. Black willow



Tools and Equipment
For Right-of-Way Clearing and Control



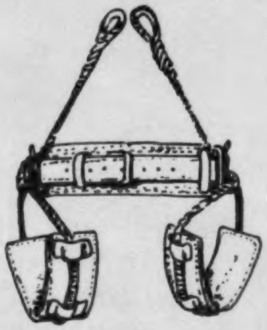
Hand Saw



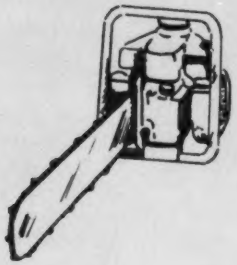
Pruner

Axe

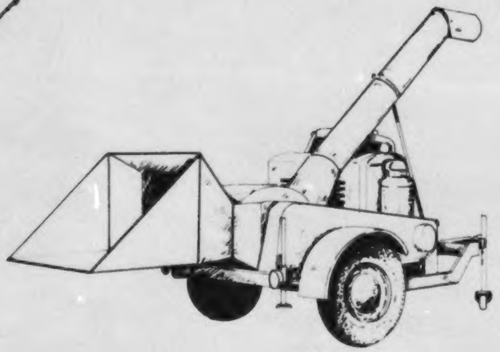
Sprayer



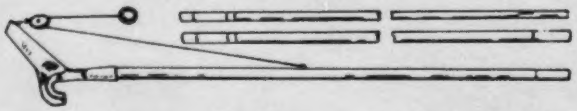
Climber's Saddle



Power Saw

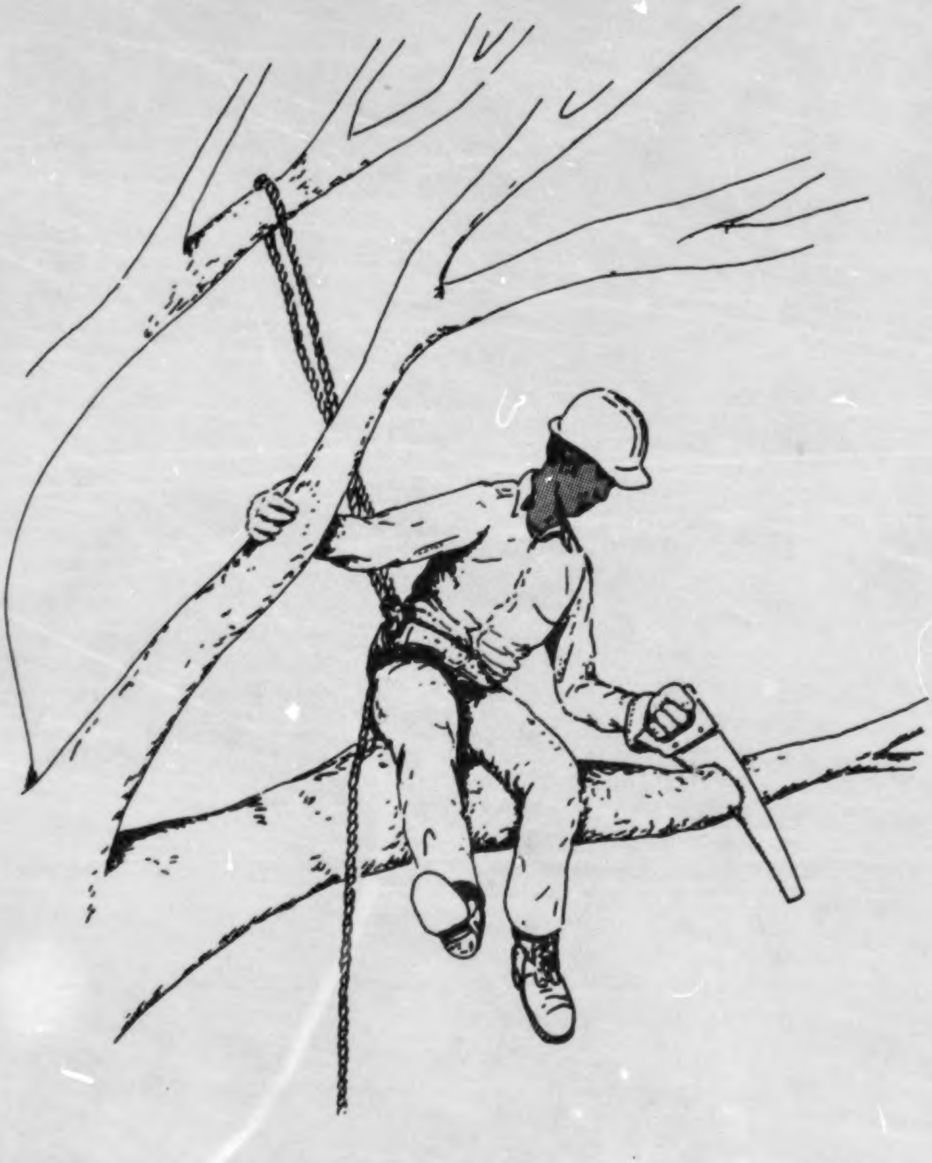


Chipper

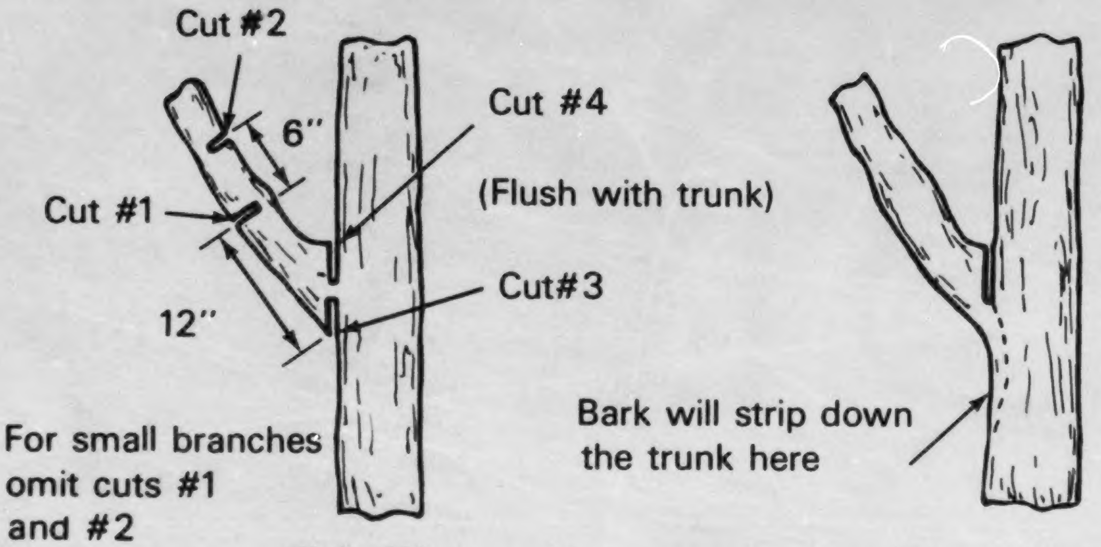


Long-Handled Trimmer

Using Safety Sling While Trimming Tree



Methods of Tree Trimming

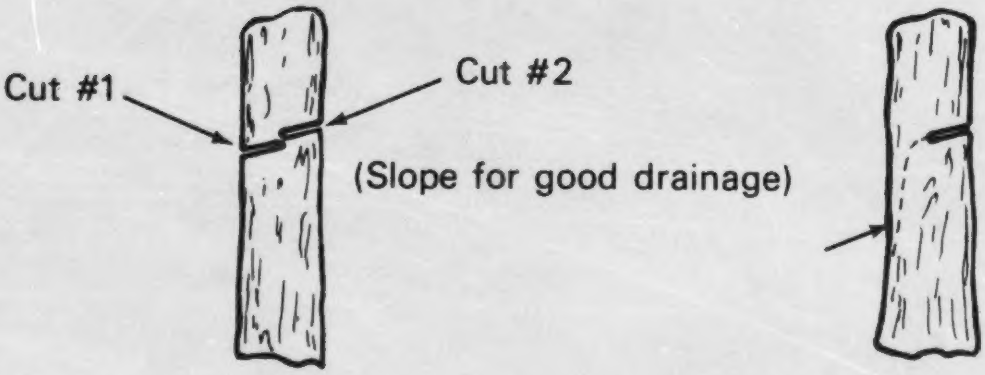

Cut #2
6"
Cut #4
(Flush with trunk)
Cut #1
Cut#3
12"
For small branches omit cuts #1 and #2
Bark will strip down the trunk here

Right Way

Wrong Way

REMOVAL OF HEAVY SIDE LIMB

REMOVAL OF VERTICAL LIMB



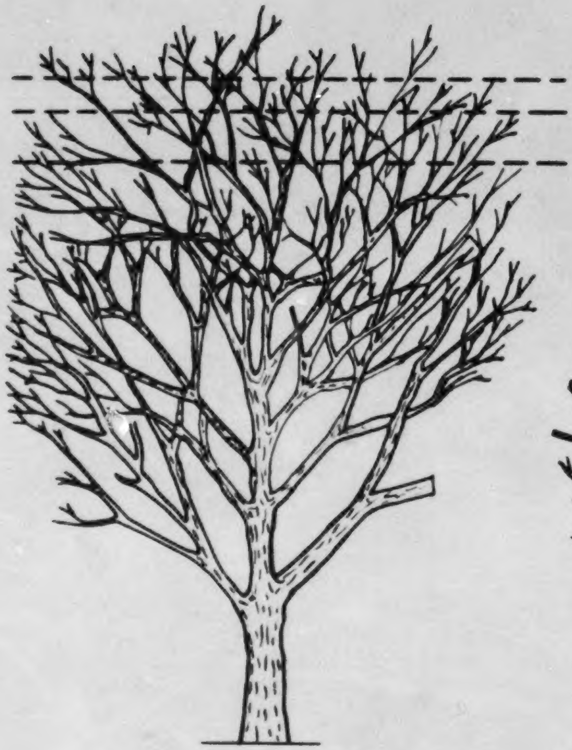
Right Way

Wrong Way

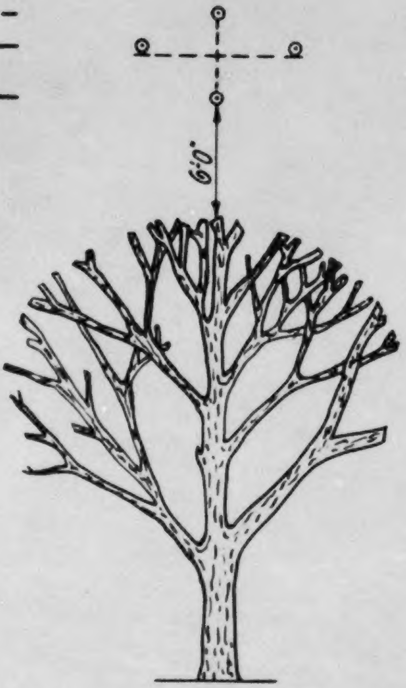
Note: Coat final cut with tree paint

Methods of Tree Trimmimg

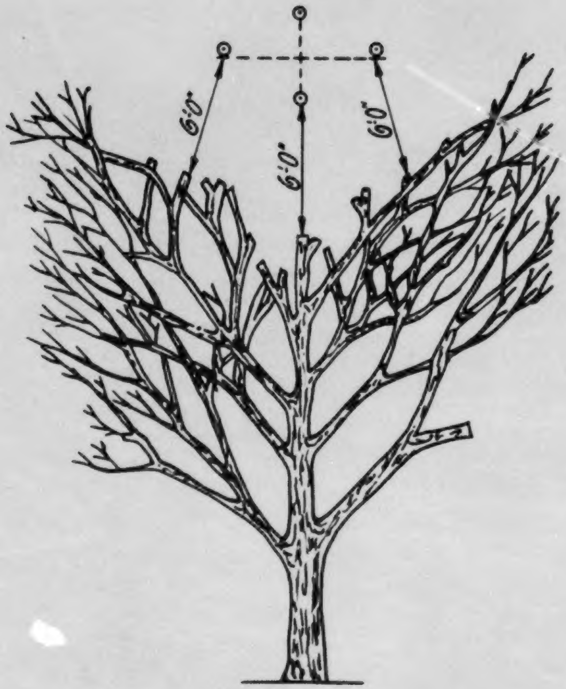
(Continued)



Before Trimming



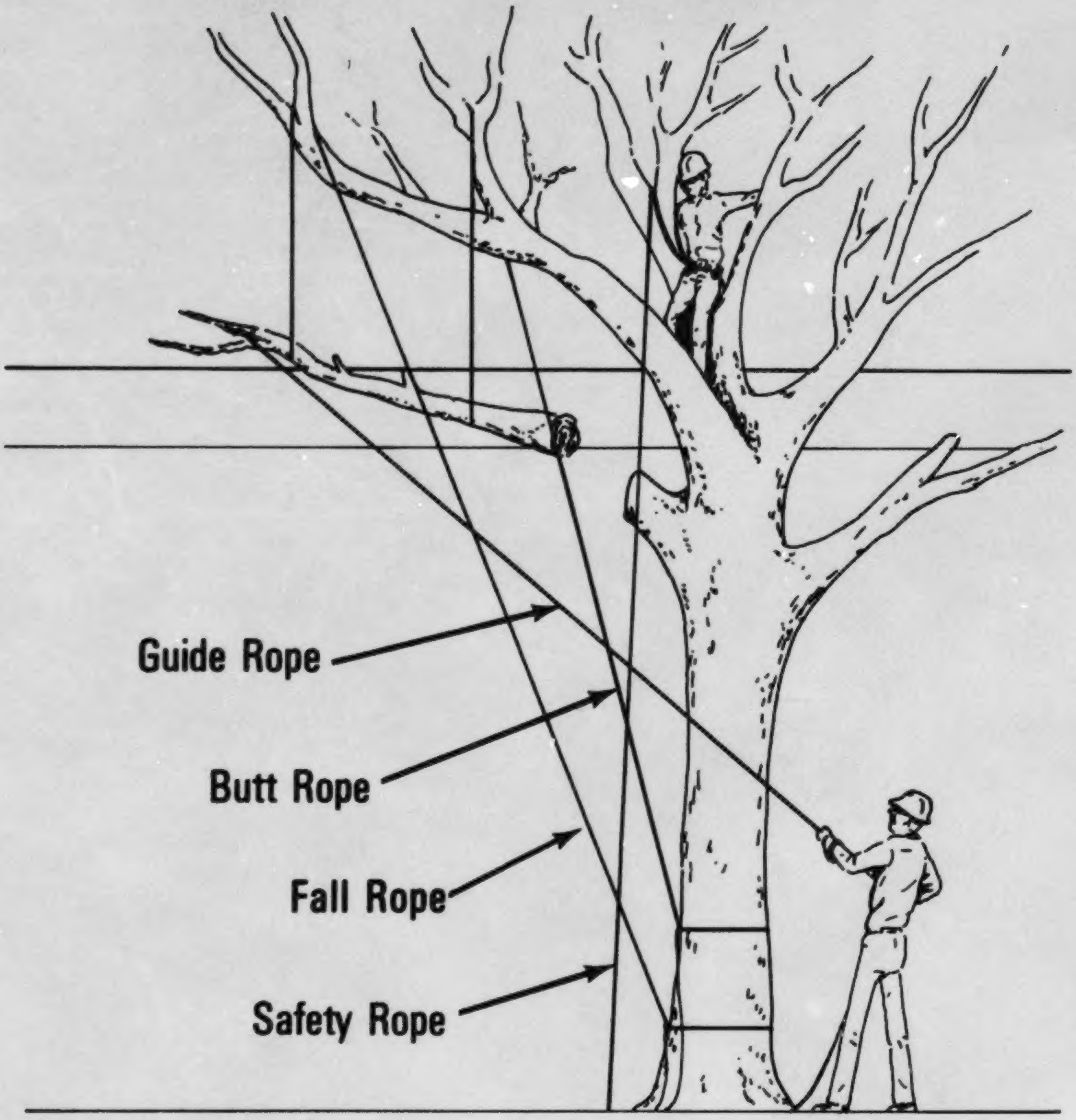
Right Way



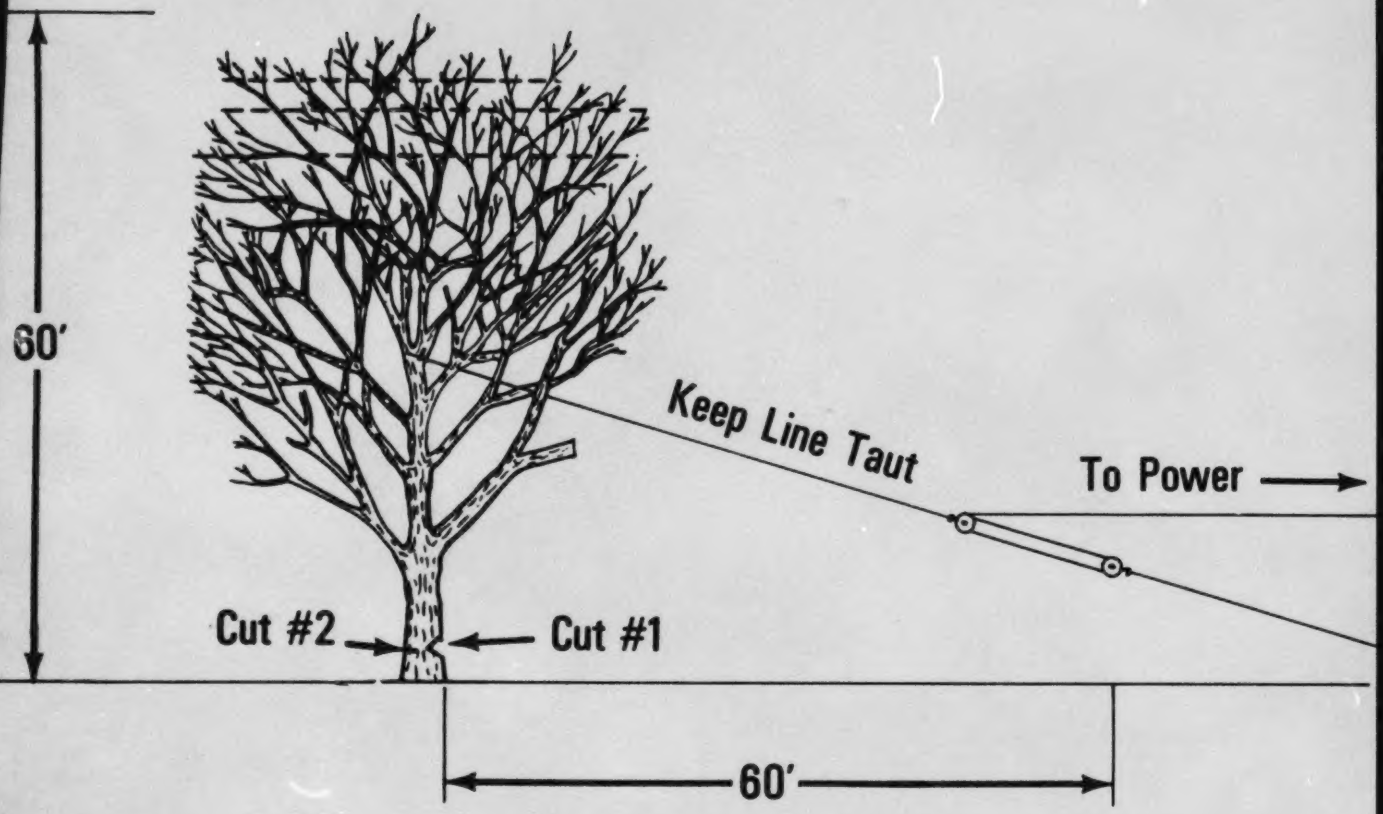
Wrong Way

NOTE: No parts of tree should be closer than 6'-0" from open wiring.
Trimming should leave tree with symmetrical appearance.

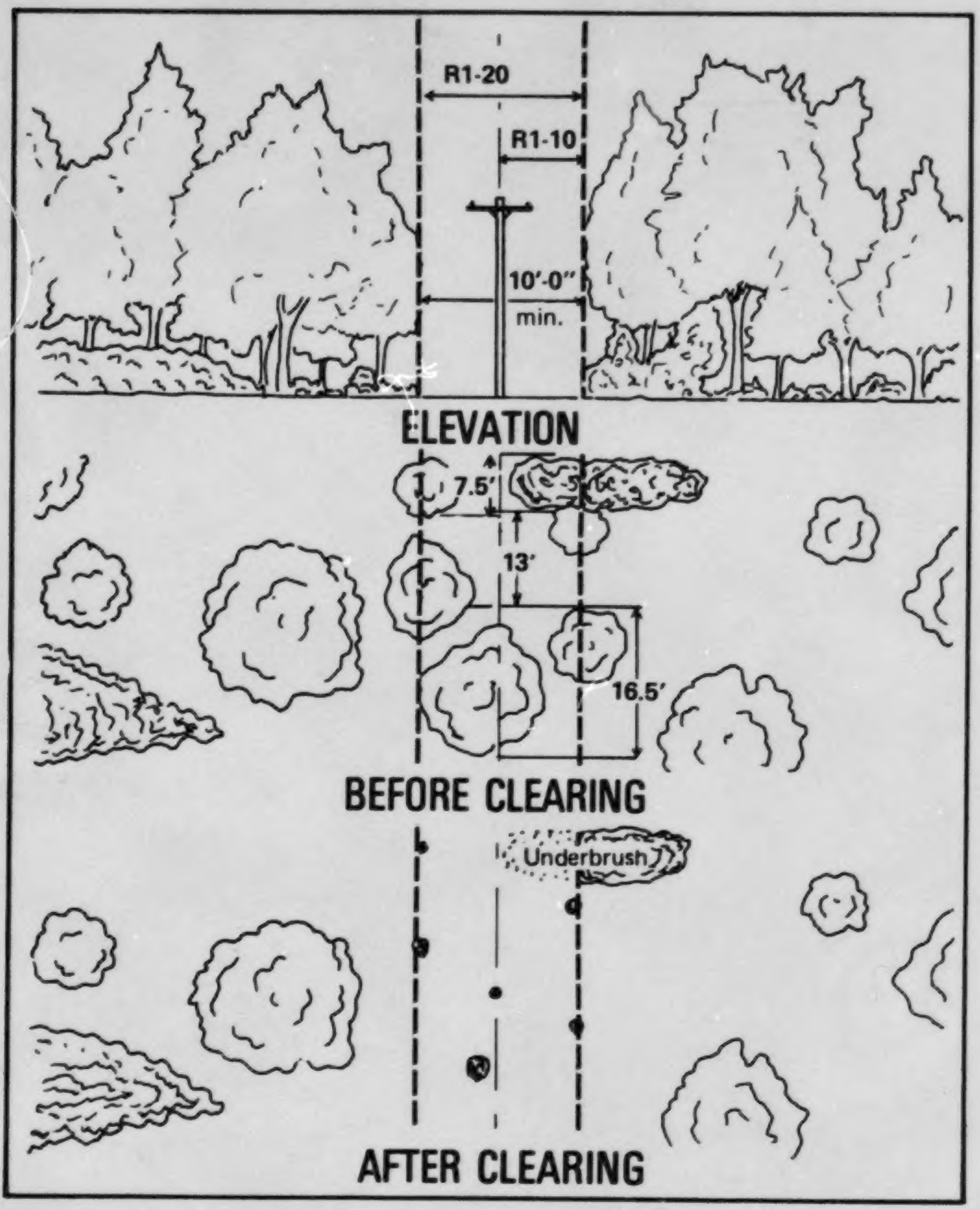
Removing Limb Hanging Over Energized Conductor



Felling A Tree



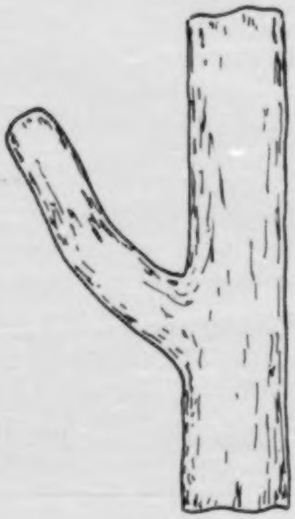
Specifications For Clearing Right-Of-Way For Distribution Line



RIGHT-OF-WAY
UNIT VIII

ASSIGNMENT SHEET #1--DRAW CUTS NEEDED TO REMOVE HEAVY LIMBS

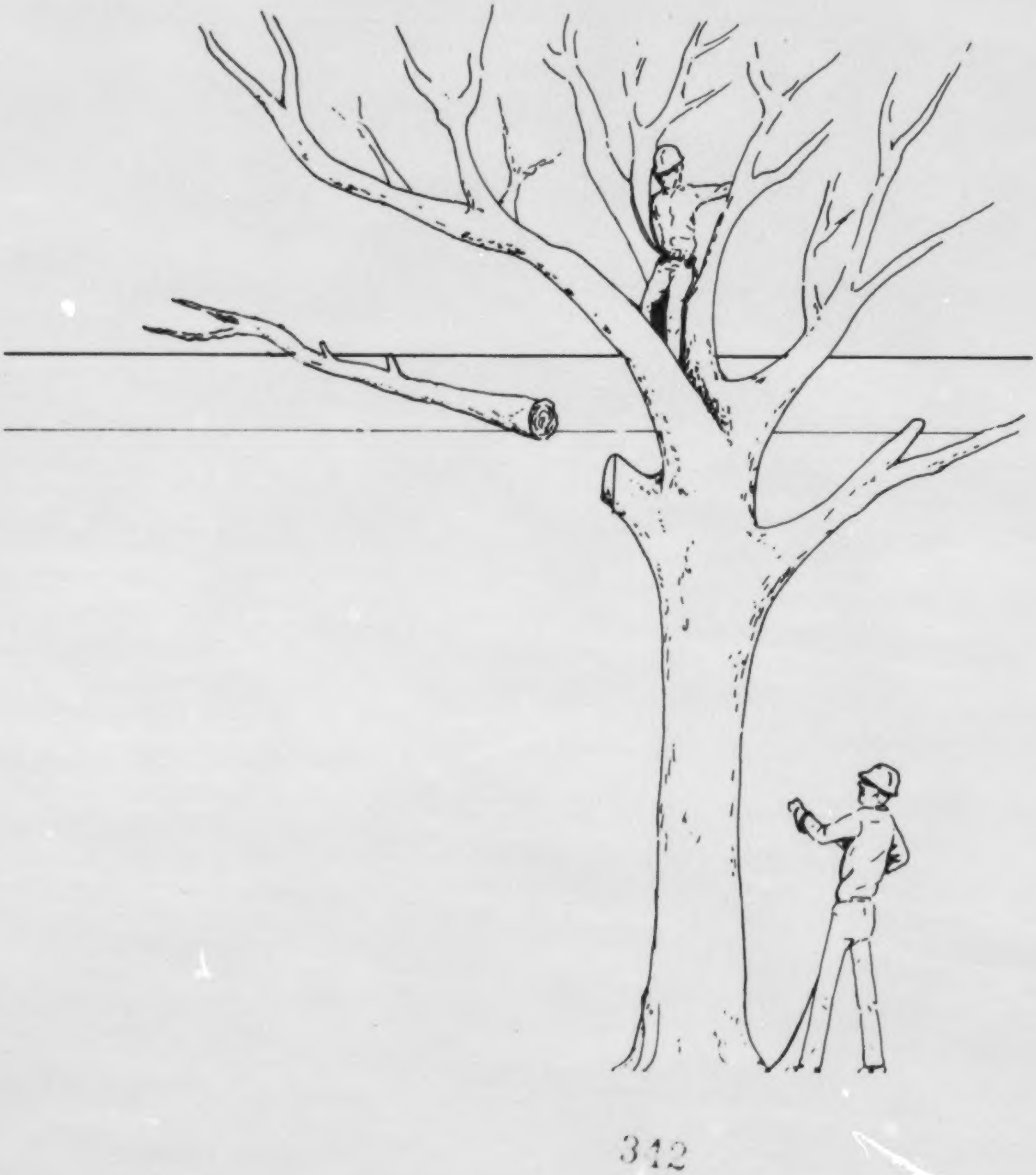
Use the following drawings to indicate the number and location of each cut needed to remove heavy side and vertical limbs.



RIGHT-OF-WAY
UNIT VIII

ASSIGNMENT SHEET #2--DRAW PROCEDURE FOR REMOVING LIMB HANGING OVER ENERGIZED CONDUCTOR

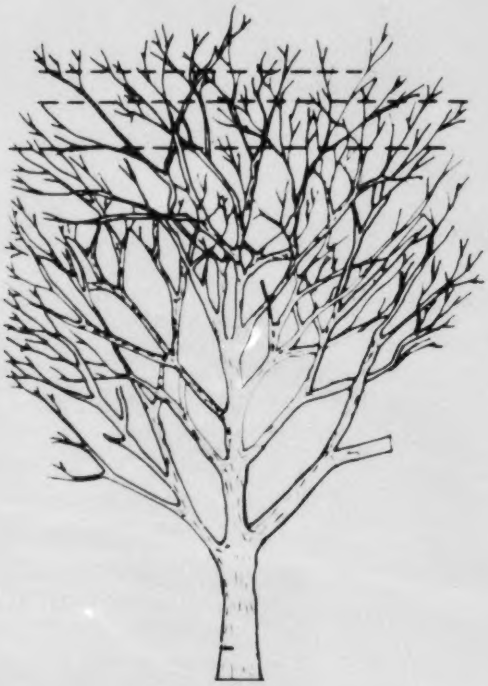
Use the illustration below to draw in the ropes necessary to secure the climber and to safely lower the severed limb hanging over the energized conductor. Label the ropes.



RIGHT-OF-WAY
UNIT VIII

ASSIGNMENT SHEET #3--DRAW PROCEDURE FOR FELLING A TREE

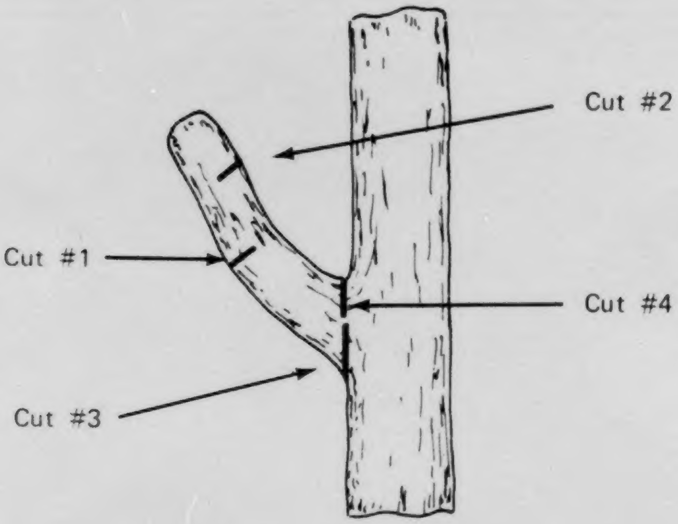
Use the following drawing to indicate the number and location of each cut and the manner of applying force to fell the tree to the right.

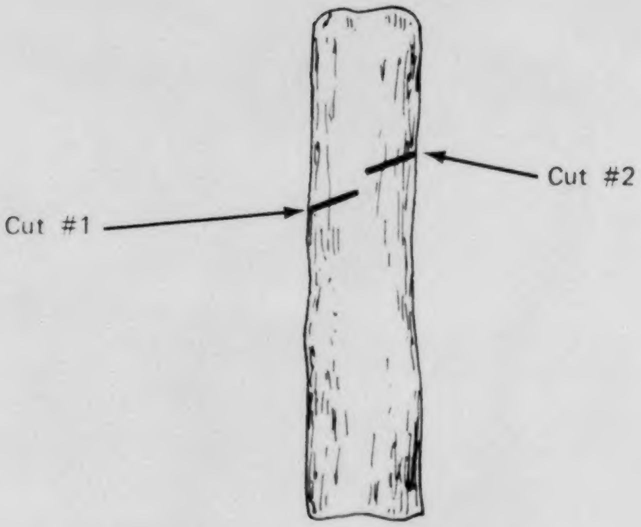


RIGHT-OF-WAY
UNIT VIII

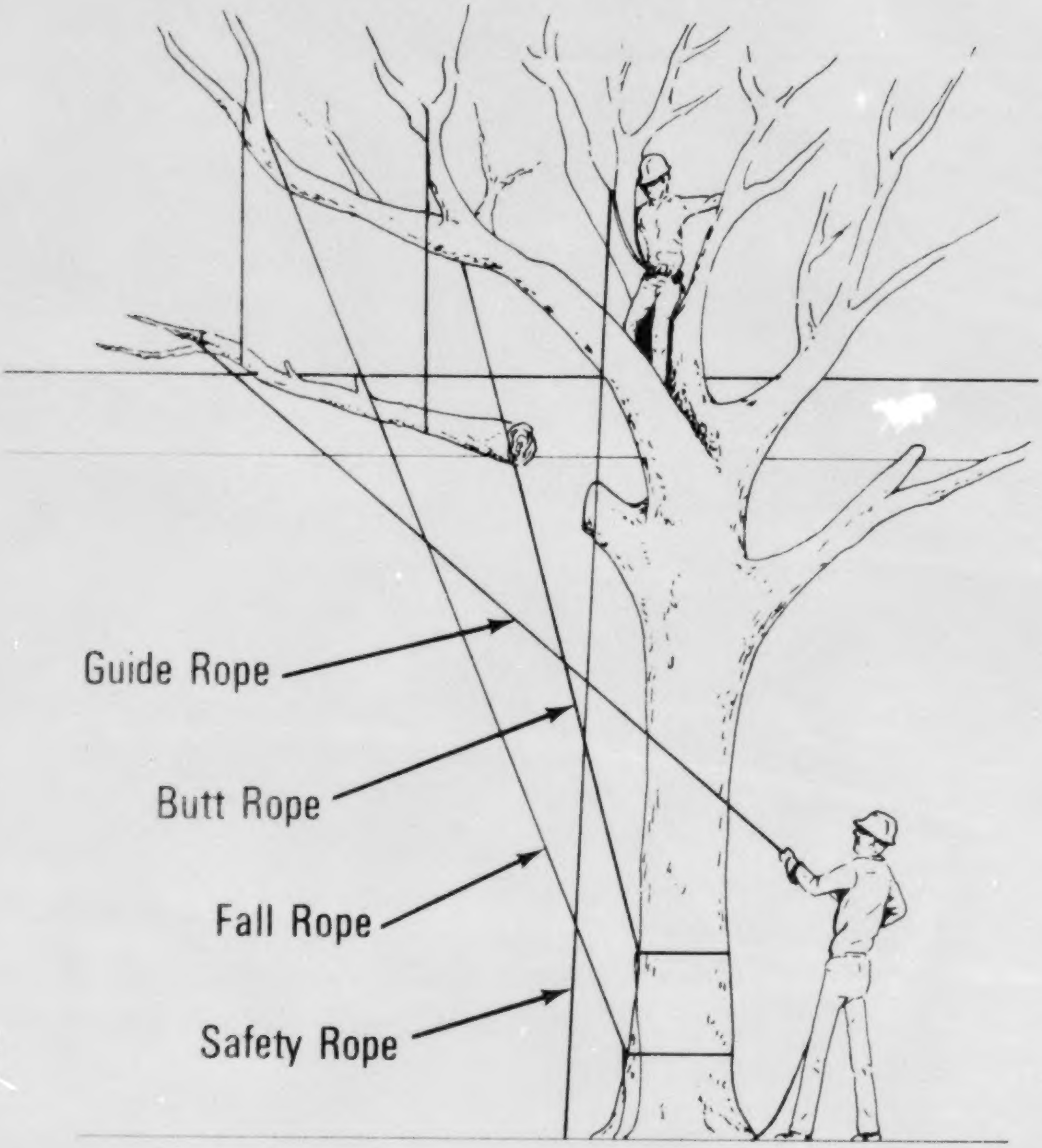
ANSWERS TO ASSIGNMENT SHEETS

Assignment Sheet #1

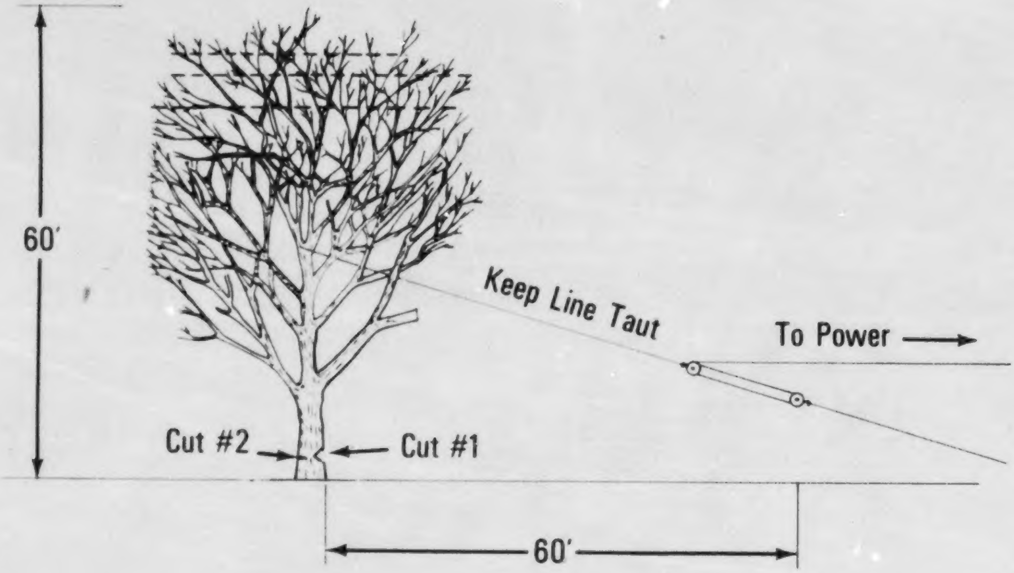




Assignment Sheet #2



Assignment Sheet #3



PLT - 383-B

RIGHT-OF-WAY
UNIT VIII

TEST

NAME ______________________________ SCORE ____________________

1. Match the terms on the right to the correct definitions.

______a. Restrict or remove new growth from right-of-way

______b. Rope used to secure climber to tree while removing limbs

______c. Shrubs, bushes, or small trees growing beneath large trees

______d. Area on which permission has been obtained to construct power lines

______e. Removal of trees and shrubs from right-of-way

______f. Recommended distance which should be maintained between conductors and growth

______g. Current not metered or sold to the consumers

______h. Interruption of electric service

1. Safety sling
2. Underbrush
3. Control
4. Right-of-way
5. Clearance
6. Clearing
7. Outage
8. Power loss

2. List four methods to maintain good public relations.

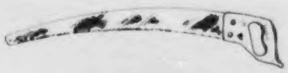
a. ____

b. ____

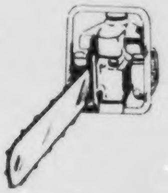
c. ____

d. ____

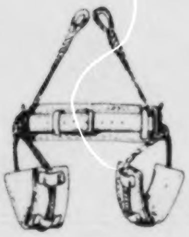
3. Identify the following tools and equipment used in right-of-way clearing and control.



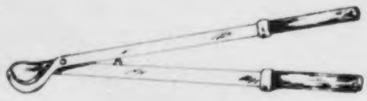
a. ____________________



b. ____________________

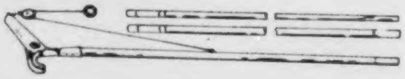


c. ______________________

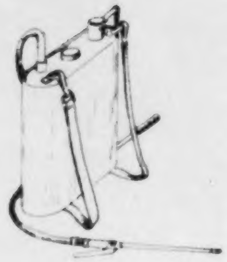


d. ______________________

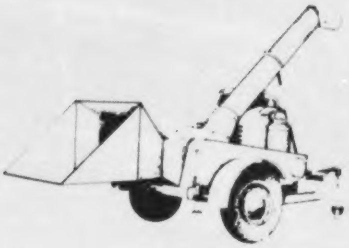
e. ______________________



f. ______________________



g. ______________________



h. ______________________

4. State the purposes of right-of-way control.

a. ____

b. ____

c. ____

d. ____

5. Select from the following list the safe working procedures by placing an "X" in the blanks provided.

   ______a. Check condition of all tools before use

   ______b. Use axes and hatchets for ground level work only

   ______c. Climb into tree with a ladder

   ______d. Rope off or barricade area to protect the public

   ______e. Post Men Working signs when working near streets or highways

   ______f. Wear eye protection

   ______g. Wear rubber gloves with protectors when working near energized conductors

   ______h. Use power saw below shoulder level only

   ______i. Climb into all trees with tree climbing tools

   ______j. Park vehicles a safe distance from work area

   ______k. Do not use power saw while working in a tree

   ______l. Keep a separation of at least 10 feet between persons cutting brush

   ______m. Use safety sling while trimming tree

   ______n. Check for overhead power lines

6. Select the proper methods of tree trimming from the following list by placing an "X" in the blanks provided.

   ______a. Start first cut on top side of limb

   ______b. Remove limb flush with trunk

   ______c. Start second cut on top side of limb

   ______d. Slope cut on vertical limbs for good drainage

7. List steps to remove limb hanging over an energized conductor.

   a. ______________________________

   b. ______________________________

   c. ______________________________

   d. ______________________________

   e. ______________________________

f. ______

g. ______

h. ______

i. ______

8. List steps to fell a tree.

a. ______

______

b ______

c. ______

9. State the specifications for clearing right-of-way for distribution line.

a. ______

b. ______

c. ______

10. List two types of right-of-way control for each of the following methods.

a. Clearing

1) ______

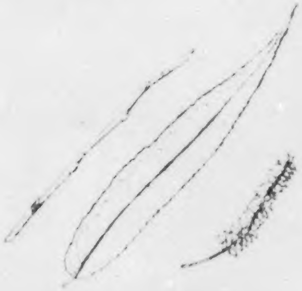
2) ______

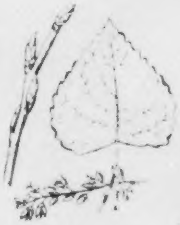
b. Chemical

1) ______

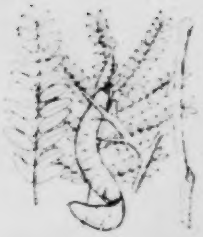
2) ______

11. Identify the following trees that grow rapidly.

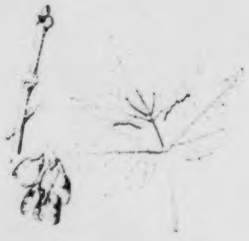




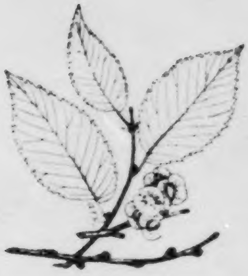
a. ______ b. ______



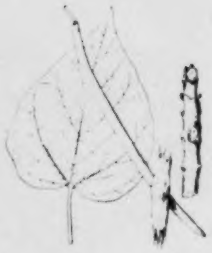
c. ____________________



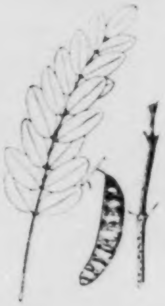
d. ____________________



e. ____________________



f. ____________________



g. ____________________

RIGHT-OF-WAY
UNIT VIII

ANSWERS TO TEST

1. Match the terms on the right to the correct definitions.

   3 a. Restrict or remove new growth from right-of-way

   1 b. Rope used to secure climber to tree while removing limbs

   2 c. Shrubs, bushes, or small trees growing beneath large trees

   4 d. Area on which permission has been obtained to construct power lines

   6 e. Removal of trees and shrubs from right-of-way

   5 f. Recommended distance which should be maintained between conductors and growth

   8 g. Current not metered or sold to the consumers

   7 h. Interruption of electric service

   1. Safety sling
   2. Underbrush
   3. Control
   4. Right-of-way
   5. Clearance
   6. Clearing
   7. Outage
   8. Power loss

2. List four methods to maintain good public relations.

   a. Obtain permission

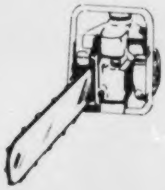
   b. Be sure owner understands what work is to be done

   c. Dispose of brush by burning, chipping, or hauling away according to landowner's wishes

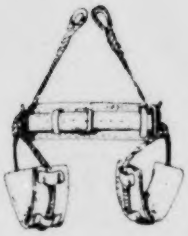
   d. Respect owner's property rights

3. Identify the following tools and equipment used in right-of-way clearing and control.

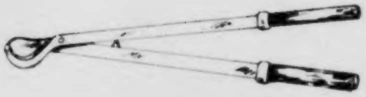
a. Hand saw



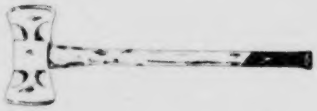
b. Power saw



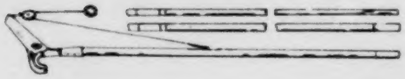
c. Climber's saddle



d. Pruners

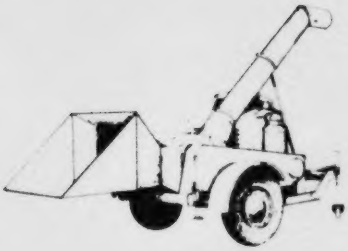


e. Axe



f. Long-handled trimmer

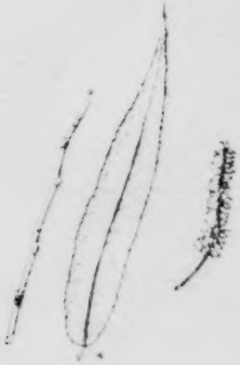
g. Sprayer



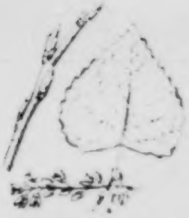
h. Chipper

4. State the purposes of right-of-way control.
   - a. Prevent electric service outages
   - b. Prevent damage to conductors
   - c. Reduce power loss
   - d. Allow access to electrical system

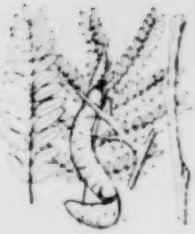
11. Identify the following trees that grow rapidly.



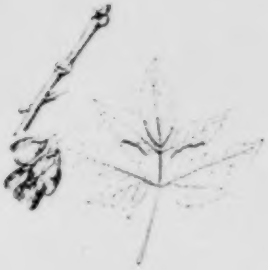
a. Black willow



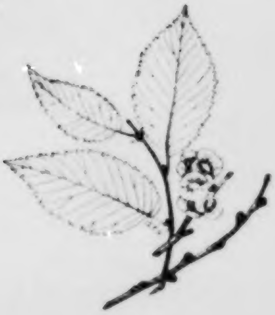
b. Cottonwood



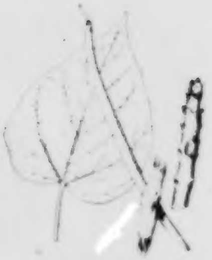
c. Honey locust



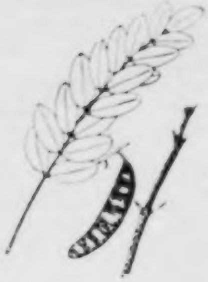
d. Box elder



e. Chinese elm



f. Catalpa



g. Black locust

DISTRIBUTION TRANSFORMERS
UNIT IX

UNIT OBJECTIVE

After completion of this unit, the student should be able to identify the parts of a CSP transformer and classify types of transformers as air-cooled or oil-cooled. The student should be able to record information found on a transformer nameplate and complete a transformer record sheet. This knowledge will be evidenced through demonstration and by scoring 85 percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms associated with transformers to the correct definitions.
2. State the functions of a transformer.
3. Identify parts of a CSP transformer.
4. Distinguish between additive and subtractive polarity as they relate to transformers.
5. List kinds of transformers.
6. Match types of transformers to the correct descriptions.
7. Classify types of transformers as oil-cooled or air-cooled.
8. Record information found on a transformer nameplate.
9. Complete a transformer record sheet.

DISTRIBUTION TRANSFORMERS
UNIT IX

SUGGESTED ACTIVITIES

I. Suggested activities for instructor:

   A. Provide student with objective sheet.

   B. Provide student with information and assignment sheets.

   C. Make transparencies.

   D. Discuss unit and specific objectives.

   E. Discuss information and assignment sheets.

   F. Give test.

II. Unit references:

   A. *Distribution Transformer Manual.* GET-2485K. Hickory, North Carolina: General Electric, 1975.

   B. Kurtz, Edwin B., and Shoemaker, Thomas M. *The Lineman's and Cableman's Handbook.* 5th ed. New York: McGraw-Hill Book Co., 1976.

DISTRIBUTION TRANSFORMERS
UNIT IX

INFORMATION SHEET

I. Terms and definitions

A. Transformer tank--Metal enclosure which houses the transformer core, coils, and cooling oil

B. High-voltage bushing--Bushing made of porcelain or other nonconductive material which insulates high voltage from the transformer tank

C. Low-voltage bushing--Bushing made of nonconductive material which insulates the low voltage from the transformer tank

D. CSP transformer--Transformer which has a built-in low-voltage circuit breaker

(NOTE: CSP stands for *contains self-protection.*)

E. Conventional transformer--Transformer installed with an external fuse for protection

(NOTE: Conventional transformers may have more than one high-voltage bushing.)

F. Core and coil assembly--Unit composed of primary and secondary windings on a laminated metal core

G. KVA (kilovolt-ampere)--Rating of a transformer

(NOTE: KVA is the apparent power rather than the true power. KVA is found by multiplying the secondary voltage by the full load amperes and dividing by 1000.)

H. Impedance--Opposition to current flow in an alternating current circuit

I. Primary winding--Winding to which voltage is applied

J. Secondary winding--Winding from which voltage is taken

K. Transformer record--Printed form used to record information from a transformer

L. Tap changer--Unit in some transformers which increases or decreases the number of turns on the primary winding

M. Transformer oil--Oil used in transformer tank to insulate and cool core and coil assembly

INFORMATION SHEET

N. Transformer-turns ratio--Turns on the primary winding related to turns on the secondary winding

Example: 7200 volt primary 120 volt secondary
7200 ÷ 120 = 60
Ratio = 60 to 1

O. Polarity--Indicates direction of current flow through the primary winding with respect to the direction of current flow through the secondary winding

II. Functions of a transformer

A. Transfers current from one circuit to another with no physical connection

B. Transforms voltage from high voltage to low voltage

Example: Step-down transformer

C. Transforms voltage from low voltage to high voltage

Example: Step-up transformer

III. Parts of a CSP transformer (Transparency 1)

A. High-voltage bushing

B. Low-voltage bushing

C. Low-voltage circuit breaker

D. Low-voltage lead

E. Transformer tank

F. Transformer coil

G. Tank grounding lug

H. Internal high-voltage fuse

I. Lightning arrester

J. Low-voltage circuit breaker reset handle

K. Transformer core

INFORMATION SHEET

IV. Additive and subtractive polarity (Transparency 2)

- A. Additive polarity--Current flowing in one direction in the primary winding and in the opposite direction in the secondary winding
- B. Subtractive polarity--Current flowing in the same direction in both primary and secondary windings

V. Kinds of transformers

- A. Oil-cooled
- B. Air-cooled

VI. Types of transformers

- A. Pole mount--Oil-cooled transformer with side-mounted hangers installed on a pole
- B. Pad mount--Oil-cooled transformer installed on a plastic or concrete pad in commercial or residential underground distribution system
- C. Submersible--Oil-cooled transformer installed in a concrete or fiber vault for residential distribution
- D. Direct buried--Oil-cooled transformer buried in the soil and used for residential distribution
- E. Potential transformer--Air-cooled transformer used to reduce voltage for testing or metering purposes

  (NOTE: Potential transformers are sometimes referred to as *instrument transformers.*)
- F. Current transformer--Air-cooled transformer used with metering equipment
- G. Autotransformer--Oil-cooled transformer in which the primary and secondary have a common winding

  (NOTE: Autotransformers are most efficient when the voltage difference between the primary and secondary is not great.)

VII. Oil-cooled and air-cooled transformers (Transparencies 3 and 4)

- A. Oil-cooled
  - 1. Pole mount

    Example: CSP or conventional

INFORMATION SHEET

   2. Pad mount
   3. Submersible
   4. Direct buried
   5. Autotransformer

B. Air-cooled

   1. Potential
   2. Current
      a. High voltage
      b. Low voltage

VIII. Transformer nameplate information (Transparency 5, Assignment Sheets #1 and #2)

(NOTE: This information is needed when installing, removing, or changing a transformer.)

A. Primary voltage

B. Secondary voltage

C. KVA (transformer rating)

D. Polarity (additive or subtractive)

E. Impedance (percent)

F. Type (CSP or conventional)

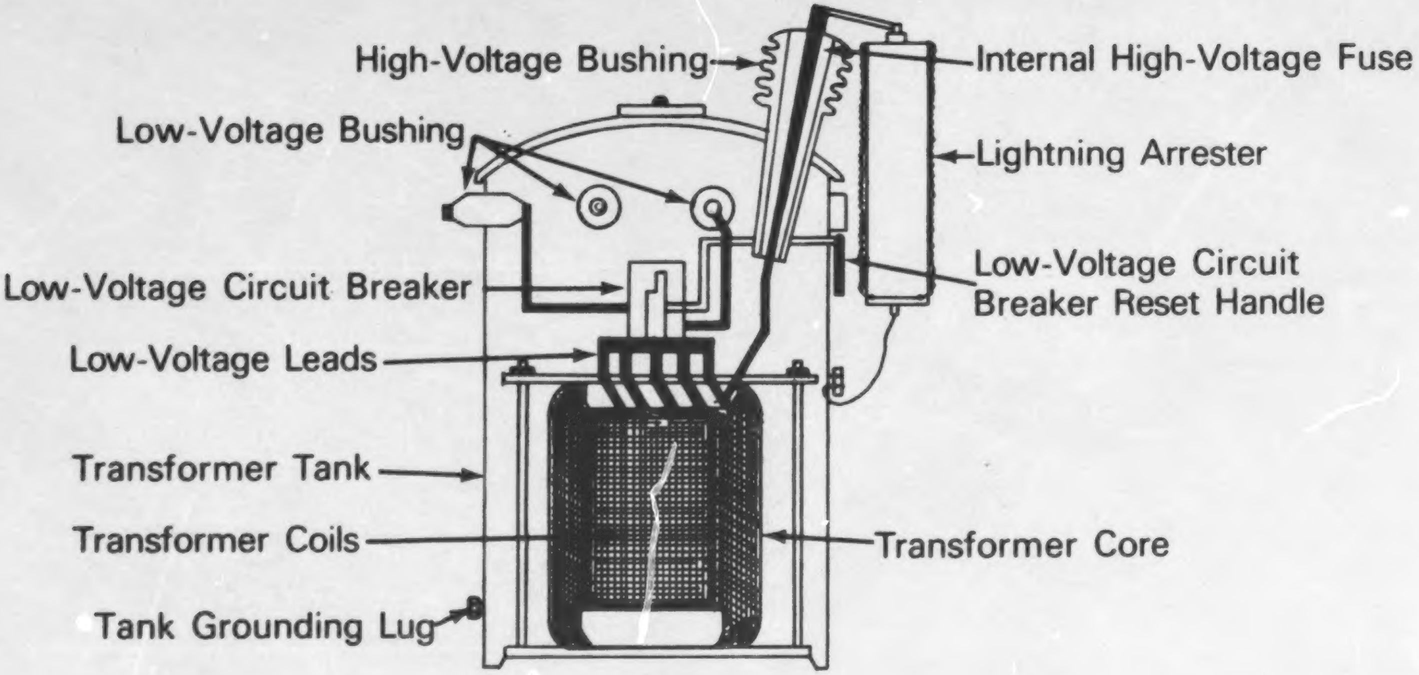
G. Phase (single- or three-phase)

H. Make (manufacturer)

I. Serial number

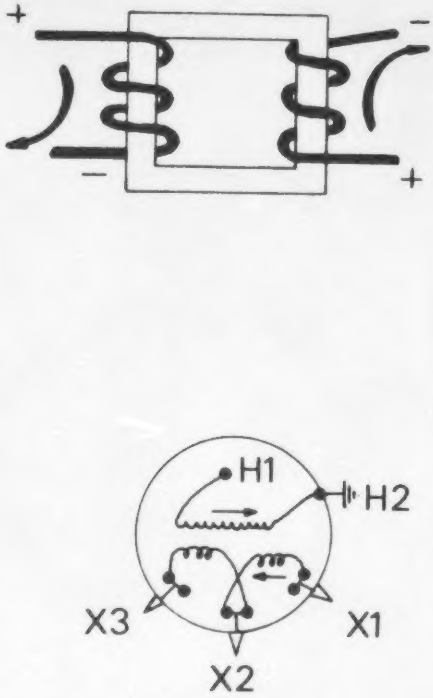
(NOTE: Most cooperatives and utilities put their own numbers on transformers. This is also part of the information needed.)

Parts Of CSP Transformer

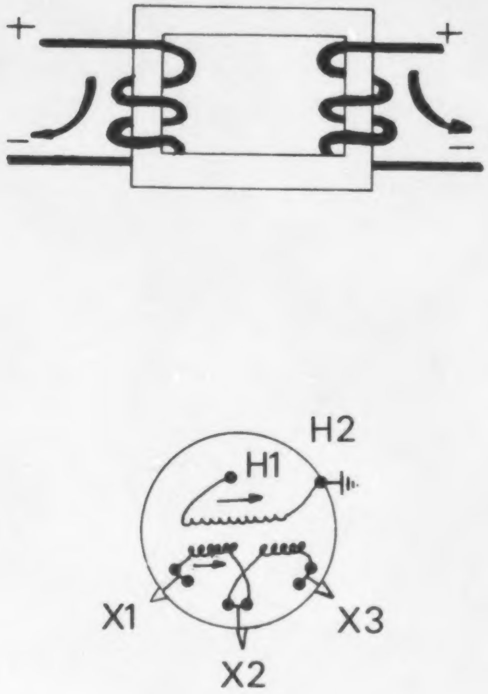


OIL COVERS CORE AND COIL ASSEMBLY

Additive And Subtractive Polarity

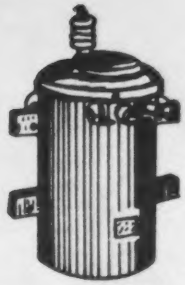


Additive

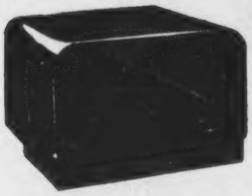


Subtractive

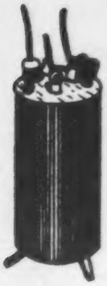
Oil-Cooled Transformers



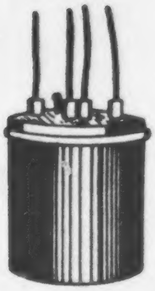
Pole Mount
(CSP or Conventional)



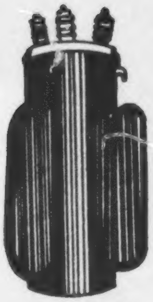
Pad Mount



Submersible



Direct Buried

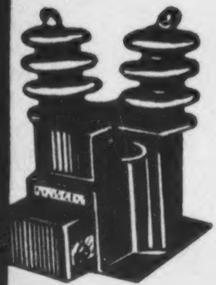


Autotransformer

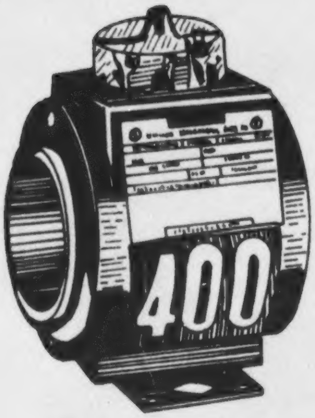
Air-Cooled Transformers

POTENTIAL

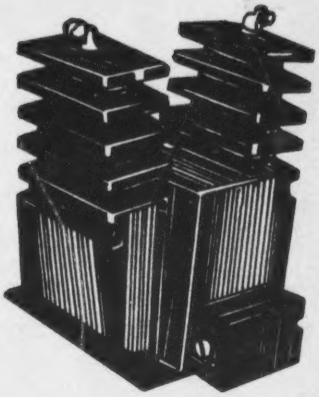
CURRENT



High Voltage



Low Voltage



High Voltage

Transformer Nameplate

SAMPSON ELECTRIC

Class A 1 Phase 60 Cycles Add. Pol. Cont. 55°C Rise

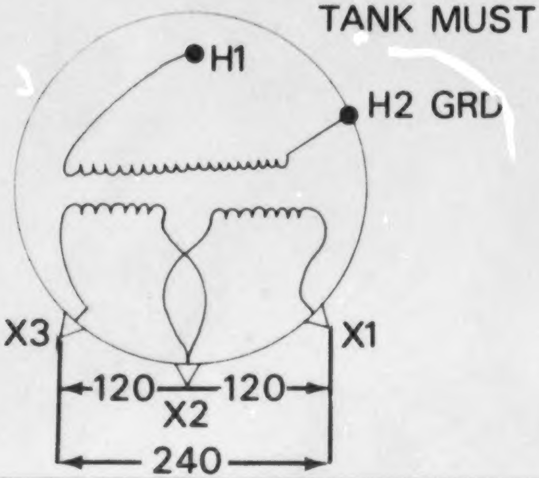
Spec. J2 311-B27794 15 Gal. 7 7NI Oil 1.7% IMP.

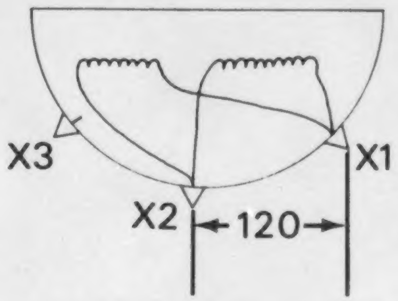
Serial No. 4S34521 25 KVA

Voltage Rating 12470 GRD. Y/7200 TO 120/240

TYPE CSP

NOTE: H2 AND X2 ARE CONNECTED TO TANK
TANK MUST BE SOLIDLY GROUNDED





DISTRIBUTION TRANSFORMERS
UNIT IX

ASSIGNMENT SHEET #1 RECORD INFORMATION FOUND ON A TRANSFORMER NAMEPLATE

Using the nameplate below, identify the following information.

Make: ______________________

Type: ______________________

Phase: ______________________

Secondary voltage: ____________

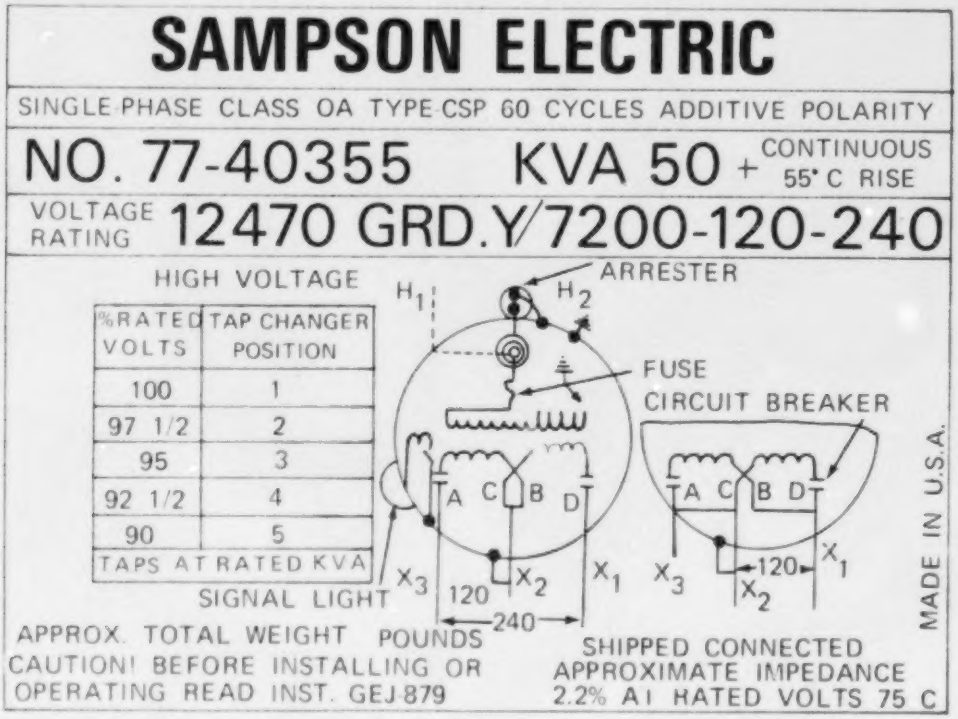
Primary voltage: ____________

Impedance: ______________________

KVA: ______________________

Polarity: ______________________

Serial no.: ______________________



SAMPSON ELECTRIC

SINGLE-PHASE CLASS OA TYPE CSP 60 CYCLES ADDITIVE POLARITY

NO. 77-40355 KVA 50 + CONTINUOUS 55° C RISE

VOLTAGE RATING 12470 GRD.Y/7200-120-240

HIGH VOLTAGE

%RATED VOLTS	TAP CHANGER POSITION
100	1
97 1/2	2
95	3
92 1/2	4
90	5
TAPS AT RATED KVA	

APPROX. TOTAL WEIGHT POUNDS

CAUTION! BEFORE INSTALLING OR OPERATING READ INST. GEJ-879

SHIPPED CONNECTED

APPROXIMATE IMPEDANCE 2.2% AT RATED VOLTS 75 C

MADE IN U.S.A.

DISTRIBUTION TRANSFORMERS
UNIT IX

ASSIGNMENT SHEET #2--COMPLETE A TRANSFORMER RECORD SHEET

Using the following nameplates, record information from nameplate "A" on the SET section of the transformer record and nameplate "B" on the REMOVE section.

A

SAMPSON ELECTRIC

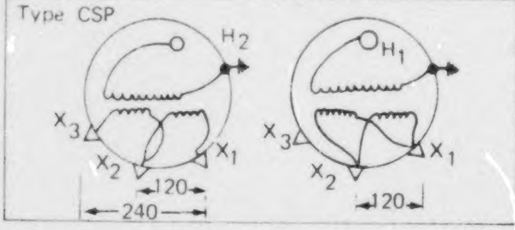
Class A 1 Phase Sub. Pol. 1.2% Imp.

Spec. J-2 74101 15 Gal Oil Cont. 55° Rise

Serial No. 37-411082 37.5 KVA

Voltage Rating 24940 Grd. Y/14400 To 120/240

Type CSP



B

KEYSTONE ELECTRIC

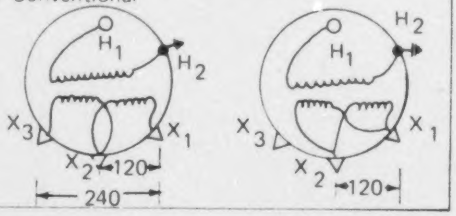
Class A 1 Phase Add. Pol. 1.5% Imp.

Spec. 177-2E41 15 Gal. Oil Cont. 55 Rise

Serial No. 5A27731 15 KVA

Voltage Rating 12470 Grd. Y/7200 To 120/240

Type Conventional



TRANSFORMER RECORD

SET

Make: ______________________

Type: ______________________

Phase: ______________________

Serial no.: ______________________

Secondary voltage: ______________________

Primary voltage: ______________________

Installed by: ______________________

Impedance: ______________________

KVA: ______________________

Polarity: ______________________

REMOVE

Make: ______________________

Type: ______________________

Phase: ______________________

Serial no.: ______________________

Secondary voltage: ______________________

Primary voltage: ______________________

Removed by: ______________________

Impedance: ______________________

KVA: ______________________

Polarity: ______________________

DISTRIBUTION TRANSFORMERS
UNIT IX

ANSWERS TO ASSIGNMENT SHEETS

Assignment Sheet #1

Make: Sampson Electric

Type: CSP

Phase: 1

Secondary voltage: 120/240

Primary voltage: 12470/7200

Impedance: 2.2%

KVA: 50

Polarity: Additive

Serial no.: 77-40355

Assignment Sheet #2

SET

Make: Sampson Electric

Type: CSP

Phase: 1

Serial no.: 37-411082

Secondary voltage: 120/240

Primary voltage: 24940/14400

Installed by: Student's name

Impedance: 1.2%

KVA: 37.5

Polarity: Subtractive

REMOVE

Make: Keystone Electric

Type: Conventional

Phase: 1

Serial no.: 5A27731

Secondary voltage: 120/240

Primary voltage: 12470/7200

Removed by: Student's name

Impedance: 1.5%

KVA: 15

Polarity: Additive

DISTRIBUTION TRANSFORMERS
UNIT IX

TEST

NAME ______________________________ SCORE ____________________

1. Match the terms on the right to the correct definitions.

______a. Winding to which voltage is applied

______b. Rating of a transformer

______c. Transformer which has a built-in low-voltage circuit breaker

______d. Transformer installed with an external fuse for protection

______e. Unit composed of primary and secondary windings on a laminated metal core

______f. Bushing made of porcelain or other nonconductive material which insulates high voltage from the transformer tank

______g. Metal enclosure which houses the transformer core, coils, and cooling oil

______h. Unit in some transformers which increases or decreases the number of turns on the primary winding

______i. Opposition to current flow in an alternating current circuit

______j. Winding from which voltage is taken

______k. Bushing made of nonconductive material which insulates the low voltage from the transformer tank

______l. Turns on the primary winding related to turns on the secondary winding

______m. Printed form used to record information from a transformer

1. High-voltage bushing
2. Low-voltage bushing
3. Transformer tank
4. CSP transformer
5. Conventional transformer
6. Core and coil assembly
7. KVA (kilovolt-ampere)
8. Impedance
9. Primary winding
10. Secondary winding
11. Transformer record
12. Tap changer
13. Transformer-turns ratio
14. Transformer oil
15. Polarity

_____n. Indicates direction of current flow through the primary winding with respect to the direction of current flow through the secondary winding

_____o. Oil used in transformer tank to insulate and cool core and coil assembly

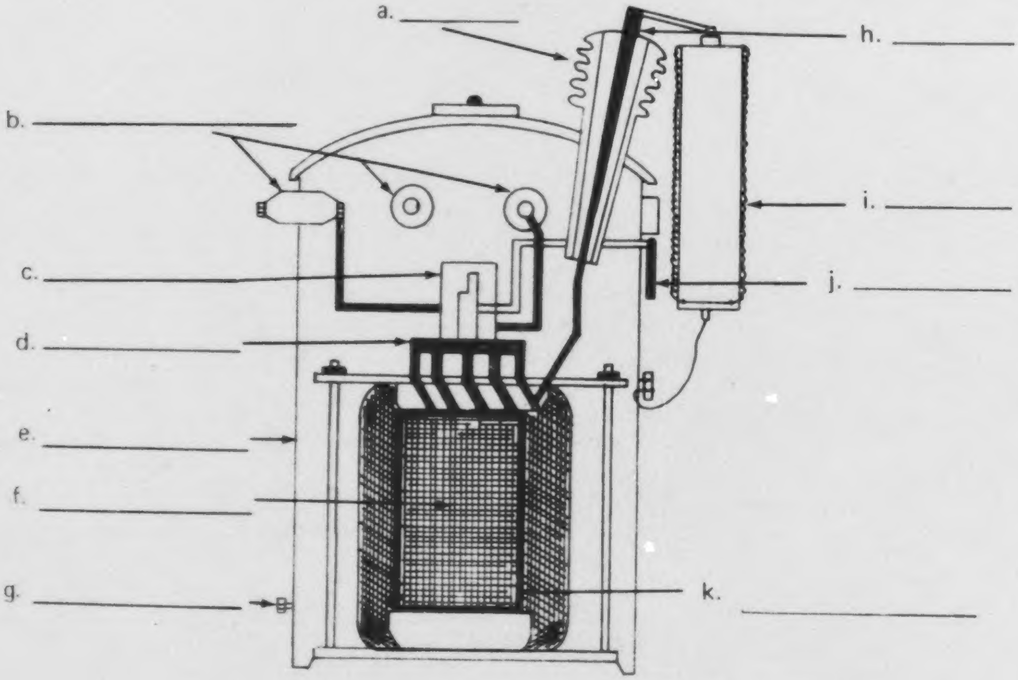
2. State three functions of a transformer.

a. ________________________________

b. ________________________________

c. ________________________________

3. Identify the parts of the CSP transformer in the diagram below.



4. Distinguish between additive and subtractive polarity as they relate to transformers by placing an "X" before the description of additive polarity.

_____a. Current flowing in the same direction in both primary and secondary windings

_____b. Current flowing in one direction in the primary winding and in the opposite direction in the secondary winding

5. List two kinds of transformers.

a. ____

b. ____

6. Match the types of transformers on the right to the correct descriptions.

______a. Oil-cooled transformer with side-mounted hangers installed on a pole

______b. Oil-cooled transformer installed on a plastic or concrete pad in commercial or residential underground distribution system

______c. Oil-cooled transformer installed in a concrete or fiber vault for residential distribution

______d. Oil-cooled transformer buried in the soil and used for residential distribution

______e. Air-cooled transformer used to reduce voltage for testing or metering purposes

______f. Oil-cooled transformer in which the primary and secondary have a common winding

______g. Air-cooled transformer used with metering equipment

1. Submersible
2. Pad mount
3. Pole mount
4. Autotransformer
5. Direct buried
6. Current transformer
7. Potential transformer

7. Classify the following types of transformers by placing an "O" in the blanks for oil-cooled and an "A" for air-cooled.

______a. Pole mount

______b. Pad mount

______c. Submersible

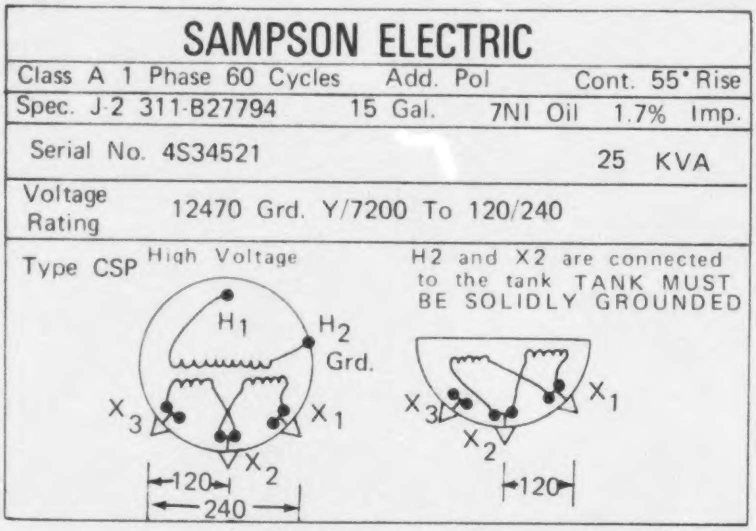
______d. Direct buried

______e. Potential

______f. Current

______g. Autotransformer

8. Record the information found on the transformer nameplate shown below.



SAMPSON ELECTRIC

Class A 1 Phase 60 Cycles Add. Pol Cont. 55° Rise

Spec. J-2 311-B27794 15 Gal. 7NI Oil 1.7% Imp.

Serial No. 4S34521 25 KVA

Voltage Rating 12470 Grd. Y/7200 To 120/240

Type CSP

H2 and X2 are connected to the tank TANK MUST BE SOLIDLY GROUNDED

Make: ____________________

Type: ____________________

Phase: ____________________

Serial no.: ________________

Primary voltage: ___________

Secondary voltage: ___________

KVA: ______________________

Polarity: ___________________

Impedance: _________________

9. Complete a transformer record sheet.

(NOTE: If this activity has not been accomplished prior to the test, ask the instructor when it should be completed.)

DISTRIBUTION TRANSFORMERS
UNIT IX

ANSWERS TO TEST

1. Match the terms on the right to the correct definitions.

9 a. Winding to which voltage is applied

7 b. Rating of a transformer

4 c. Transformer which has a built-in low-voltage circuit breaker

5 d. Transformer installed with an external fuse for protection

6 e. Unit composed of primary and secondary windings on a laminated metal core

1 f. Bushing made of porcelain or other nonconductive material which insulates high voltage from the transformer tank

3 g. Metal enclosure which houses the transformer core, coils, and cooling oil

12 h. Unit in some transformers which increases or decreases the number of turns on the primary winding

8 i. Opposition to current flow in an alternating current circuit

10 j. Winding from which voltage is taken

2 k. Bushing made of nonconductive material which insulates the low voltage from the transformer tank

13 l. Turns on the primary winding related to turns on the secondary winding

11 m. Printed form used to record information from a transformer

1. High-voltage bushing
2. Low-voltage bushing
3. Transformer tank
4. CSP transformer
5. Conventional transformer
6. Core and coil assembly
7. KVA (kilovolt-ampere)
8. Impedance
9. Primary winding
10. Secondary winding
11. Transformer record
12. Tap changer
13. Transformer-turns ratio
14. Transformer oil
15. Polarity

15 n. Indicates direction of current flow through the primary winding with respect to the direction of current flow through the secondary winding

14 o. Oil used in transformer tank to insulate and cool core and coil assembly

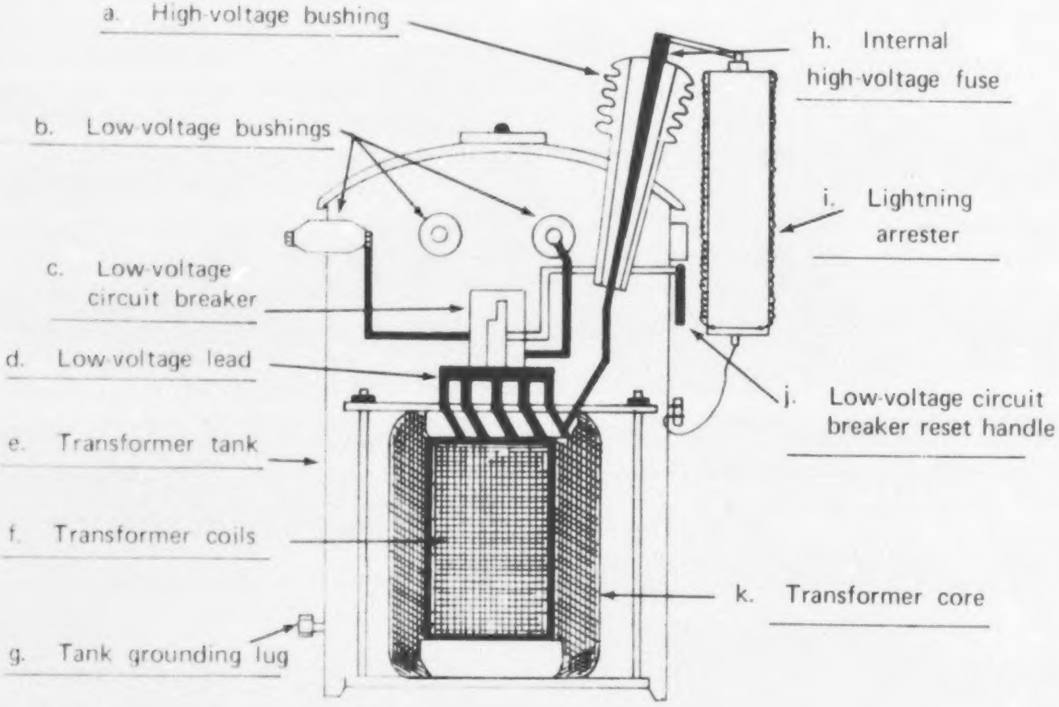
2. State three functions of a transformer.

   a. Transfers current from one circuit to another with no physical connection

   b. Transforms voltage from high voltage to low voltage

   c. Transforms voltage from low voltage to high voltage

3. Identify the parts of the CSP transformer in the diagram below.



4. Distinguish between additive and subtractive polarity as they relate to transformers by placing an "X" before the description of additive polarity.

____ a. Current flowing in the same direction in both primary and secondary windings

X b. Current flowing in one direction in the primary winding and in the opposite direction in the secondary winding

5. List two kinds of transformers.

   a. Oil-cooled

   b. Air-cooled

6. Match the types of transformers on the right to the correct descriptions.

   3 a. Oil-cooled transformer with side-mounted hangers installed on a pole

   2 b. Oil-cooled transformer installed on a plastic or concrete pad in commercial or residential underground distribution system

   1 c. Oil-cooled transformer installed in a concrete or fiber vault for residential distribution

   5 d. Oil-cooled transformer buried in the soil and used for residential distribution

   7 e. Air-cooled transformer used to reduce voltage for testing or metering purposes

   4 f. Oil-cooled transformer in which the primary and secondary have a common winding

   6 g. Air-cooled transformer used with metering equipment

   1. Submersible
   2. Pad mount
   3. Pole mount
   4. Autotransformer
   5. Direct buried
   6. Current transformer
   7. Potential transformer

7. Classify the following types of transformers by placing an "O" in the blanks for oil-cooled and an "A" for air-cooled.

   O a. Pole mount

   O b. Pad mount

   O c. Submersible

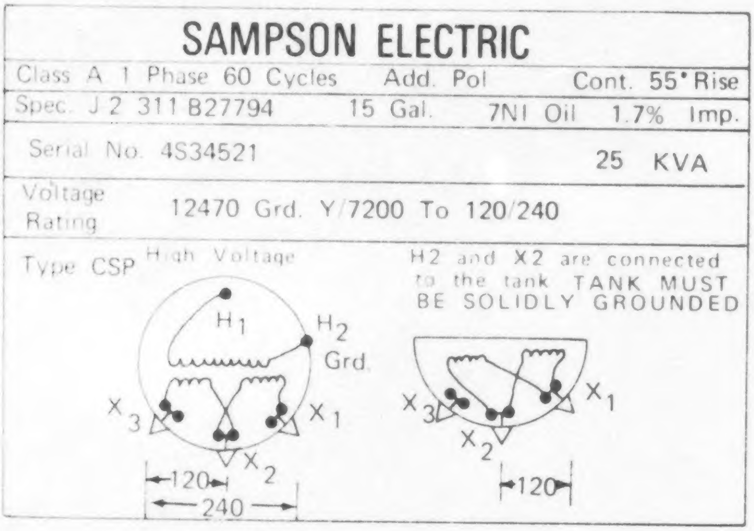
   O d. Direct buried

   A e. Potential

   A f. Current

   O g. Autotransformer

8. Record the information found on the transformer nameplate shown below.



SAMPSON ELECTRIC

Class A 1 Phase 60 Cycles Add. Pol Cont. 55° Rise

Spec. J 2 311 B27794 15 Gal. 7NI Oil 1.7% Imp.

Serial No. 4S34521 25 KVA

Voltage Rating 12470 Grd. Y/7200 To 120/240

Type CSP

H2 and X2 are connected to the tank TANK MUST BE SOLIDLY GROUNDED

Make: Sampson Electric

Type: CSP

Phase: 1

Serial no.: 4S34521

Primary voltage: 12470/7200

Secondary voltage: 120/240

KVA: 25

Polarity: Additive

Impedance: 1.7%

9. Complete a transformer record sheet.

(NOTE: This activity should be evaluated to the satisfaction of the instructor.)

POLES
UNIT I

UNIT OBJECTIVE

After completion of this unit, the student should be able to list methods used to set poles and to support unsafe poles for climbing. The student should be able to select from a list precautions to observe when handling poles and arrange in order the steps for pole inspection. The student should be able to read tables to determine classes and weights of poles. This knowledge will be evidenced by scoring 85 percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms commonly used with poles to the correct definitions.
2. List types of preservatives used on poles.
3. Match code letters to the type of preservative each represents.
4. Select from a table the classes of poles of varying lengths and circumferences.
5. Select from a list precautions to observe when handling poles.
6. Select from a table the weights of various classes and lengths of poles.
7. List methods used to set poles.
8. State the correct procedure for checking pole before climbing.
9. Arrange in order the steps for pole inspection.
10. List methods used to support unsafe poles for climbing.
11. State the correct method for storing poles.
12. Calculate the weight of a load of poles.

POLES
UNIT I

SUGGESTED ACTIVITIES

I. Suggested activities for instructor:

   A. Provide student with objective sheet.

   B. Provide student with information and assignment sheets.

   C. Make transparencies.

   D. Discuss unit and specific objectives.

   E. Discuss information and assignment sheets.

   F. Give test.

II. Unit references:

   A. Rural Electrification Administration. *Pole Inspection and Maintenance.* REA Bulletin 161-4. Washington, D.C.: U.S. Department of Agriculture, October 1974.

   B. Kurtz, Edwin B., and Shoemaker, Thomas M. *The Lineman's and Cableman's Handbook.* 5th ed. New York: McGraw-Hill Book Co., 1976.

POLES
UNIT I

INFORMATION SHEET

I. Terms and definitions

  A. Preservative--Solution forced into pole to increase its life expectancy

  B. Face--Concave side; side of greatest curvature between groundline and top of pole

  C. Groundline section--Portion of pole one foot above and two feet below groundline

  D. Short crook-Deviation from straightness in any five foot or shorter section which deviates more than one-half the diameter of the crooked section

  E. Sweep--Deviation of a pole from straightness

  F. Check--Separation of the wood along the grain

  G. Cross break--Separation of the wood across the grain

  H. Split--Lengthwise separation of the wood cells through the full diameter of the pole

  I. Shake--Separation along the grain between the rings of annual growth

II. Types of preservatives used on poles

  A. Oil-borne

  Example: Creosote penta

  B. Water-borne

  Example: Arsenates of copper

III. Preservatives and their code letters

Preservative Solution	Code
Creosote	C
Creosote/coal tar solution	T
Creosote/petroleum solution	X
Copper naphthenate solution	N
Penta (pentachlorophenal) solution	P
Salt solution	S

(NOTE: Gloves and protective clothing should always be worn when working with chemically treated poles and crossarms.)

INFORMATION SHEET

IV. Classes of poles according to dimensions (Assignment Sheet #1)

Class		1	2	3	4	5	6	7	9	10
Minimum Circumference at Top (Inches)		27	25	23	21	19	17	15	15	12
Length of Pole (Feet)	Groundline Distance from Butt (Feet)	Minimum Circumference at 6 Feet from Butt (Inches)								
20	4	31.0	29.0	27.0	25.0	23.0	21.0	19.5	17.5	14.0
25	5	33.5	31.5	29.5	27.5	25.5	23.0	21.5	19.5	15.0
30	5 1/2	36.5	34.0	32.0	29.5	27.5	25.0	23.5	20.5	
35	6	39.0	36.5	34.0	31.5	29.0	27.0	25.0		
40	6	41.0	38.5	36.0	33.5	31.0	28.5	26.5		
45	6 1/2	43.0	40.5	37.5	35.0	32.5	30.0	28.0		
50	7	45.0	42.0	39.0	36.5	34.0	31.5	29.0		
55	7 1/2	46.5	43.5	40.5	38.0	35.0	32.5			
60	8	48.0	45.0	42.0	39.0	36.0	33.5			
65	8 1/2	49.5	46.5	43.5	40.5	37.5				
70	9	51.0	48.0	45.0	41.5	38.5				
75	9 1/2	52.5	49.0	46.0	43.0					
80	10	54.0	50.5	47.0	44.0					
85	10 1/2	55.0	51.5	48.0						
90	11	56.0	53.0	49.0						
95	11	57.0	54.0	50.0						
100	11	58.5	55.0	51.0						
105	12	59.5	56.0	52.0						
110	12	60.5	57.0	53.0						
115	12	61.5	58.0							
120	12	62.5	59.0							
125	12	63.5	59.5							

Example: A 35-foot class 5 pole would measure at least 19" circumference at the top and at least 29" circumference 6' from the butt

V. Precautions to observe when handling poles

A. Use suitable equipment to lift pole

B. Attach sling or cable to pole by laying sling on ground and rolling pole onto sling

C. Move pole with cant hook or bar by working from the ends of pole

INFORMATION SHEET

D. Roll pole away from yourself when moving it

E. Do not stand or walk on stacked poles

F. Do not use cant hook or pole carrying hook in groundline section of pole

G. Do not drop pole from vehicle or pole rack

H. Do not drag pole

VI. Weights of poles (Assignment Sheet #2)

Length of Pole in Feet	Class						
	1	2	3	4	5	6	7
	Pounds						
25	990	811	674	573	491	422	344
30	1279	1082	921	784	660	550	454
35	1568	1343	1155	1004	862	743	646
40	1884	1623	1403	1219	1059	921	807
45	2223	1911	1664	1444	1274	1114	976
50	2585	2214	1925	1687	1494	1329	1169
55	2993	2567	2200	1934	1719	1563	
60	3451	2943	2512	2186	1953	1801	
65	4015	3341	2814	2457	2237		
70	4620	3781	3144	2732	2488		
75	5198	4235	3506	3021			
80	6400	5170	4240	3615			
85	7200	5745	4690				
90	8140	6405	5160				

Example: A 30-foot class 3 pole would weigh 921 pounds

(NOTE: Pole weight is an important factor when loading poles on mobile equipment to prevent overloading equipment.)

VII. Methods of setting poles

A. Pike (Transparency 1)

B. Gin pole (Transparency 2)

C. A-frame (Transparency 3)

D. Boom or digger derrick (Transparency 4)

INFORMATION SHEET

VIII. Procedure for checking pole before climbing

- A. Check pole brand for proper depth
- B. Inspect pole visually for unauthorized attachments and cracked or broken insulators

  (NOTE: A cracked or broken insulator may shatter when sounding or climbing a pole. Severe injury can result from falling porcelain.)

- C. Sound pole with hammer

  (NOTE: A crisp, solid sound indicates that the wood is good. A dull sound indicates decay and a hollow sound indicates a hollow heart.)

- D. Check for woodpecker holes and loose hardware

IX. Steps for pole inspection

- A. Read and record brand information
- B. Check for broken insulators
- C. Sound the pole above ground
- D. Excavate the pole to a depth of 18"
- E. Sound the pole below ground

  (NOTE: If there is an indication of unsound wood, step "F" should be included in inspection.)

- F. Bore the pole with a 3/8" bit

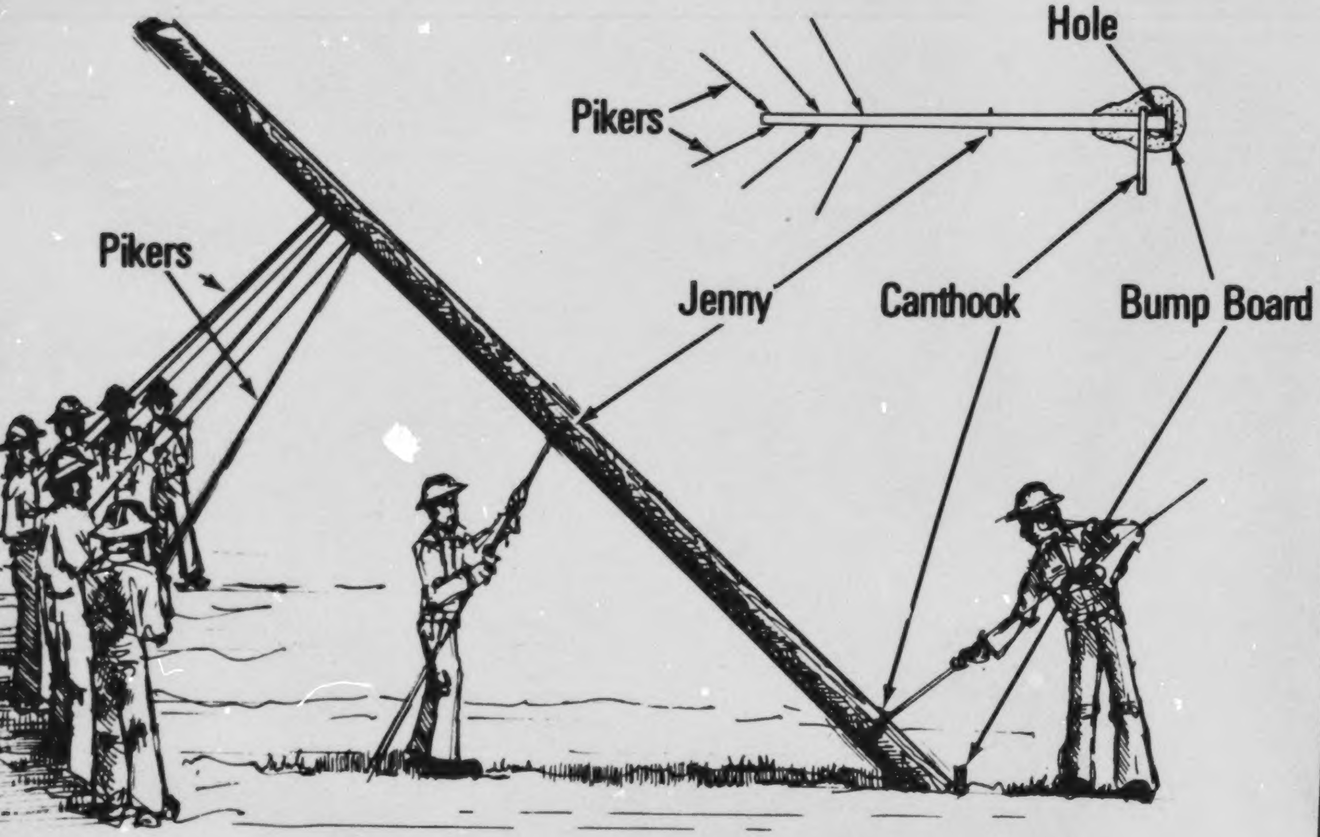
  (NOTE: All bored holes should be filled with tight-fitting, treated plugs.)

X. Methods of supporting unsafe poles for climbing

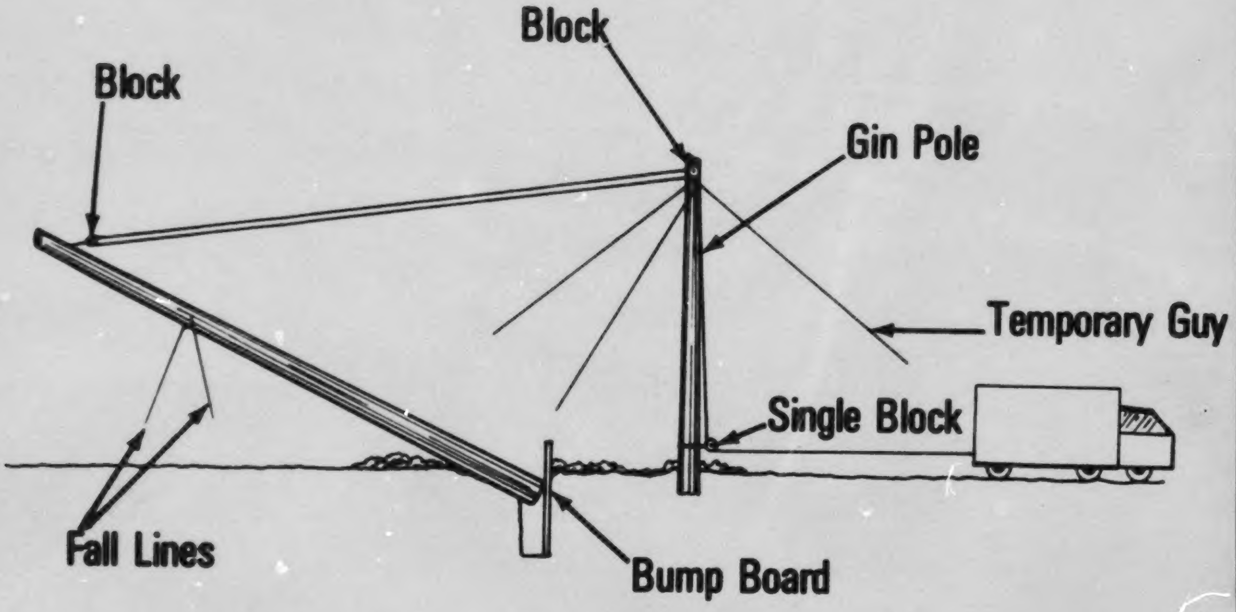
- A. A-frame and metal stub (Transparency 5)
- B. Temporary guy (Transparency 6)
- C. Digger derrick (Transparency 7)
- D. Pole pike
- E. Pole stub

XI. Storing poles-Poles should be stored on racks with each layer separated or laid at a right angle to the layer below to allow for circulation of air

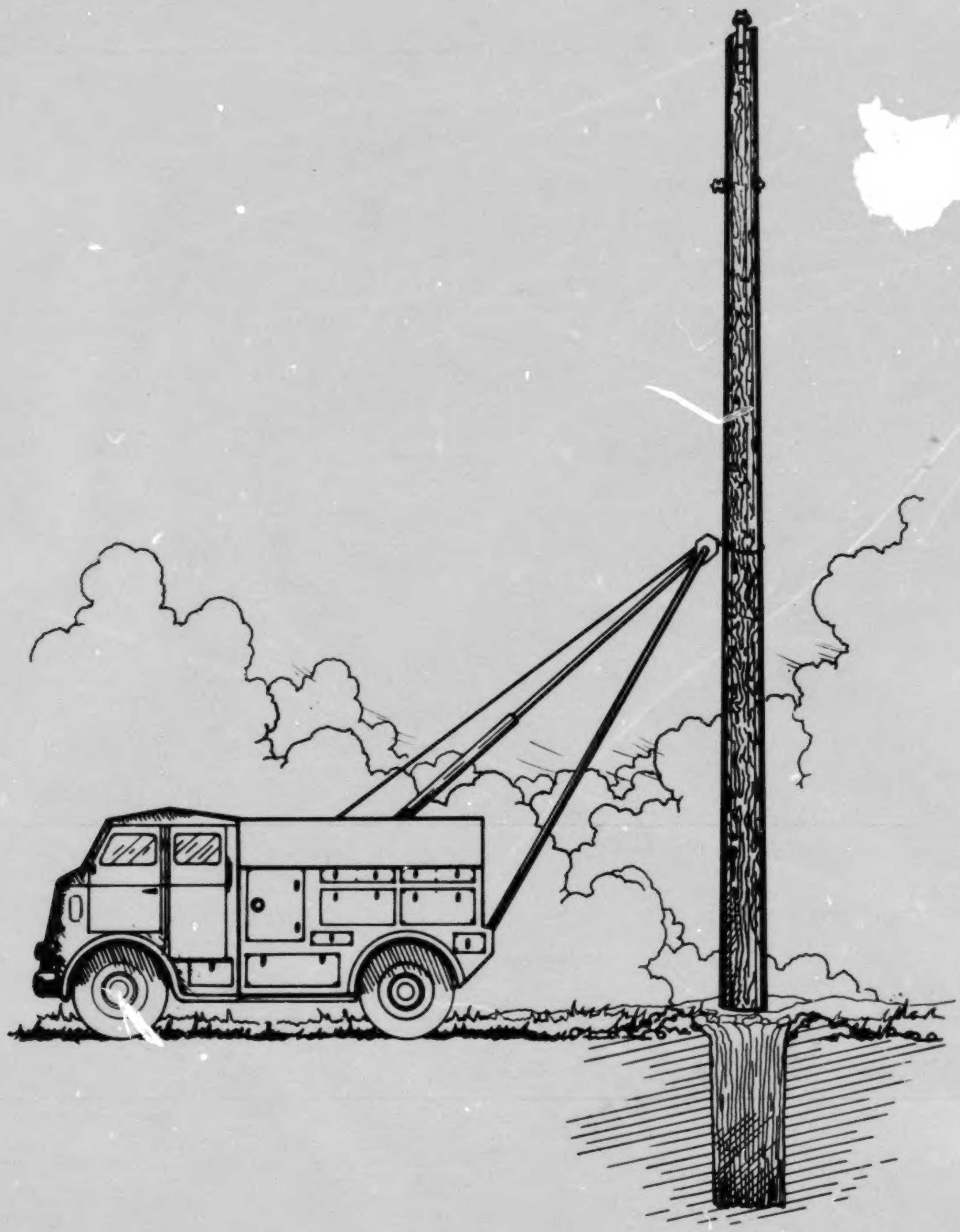
Setting Pole With Pikes



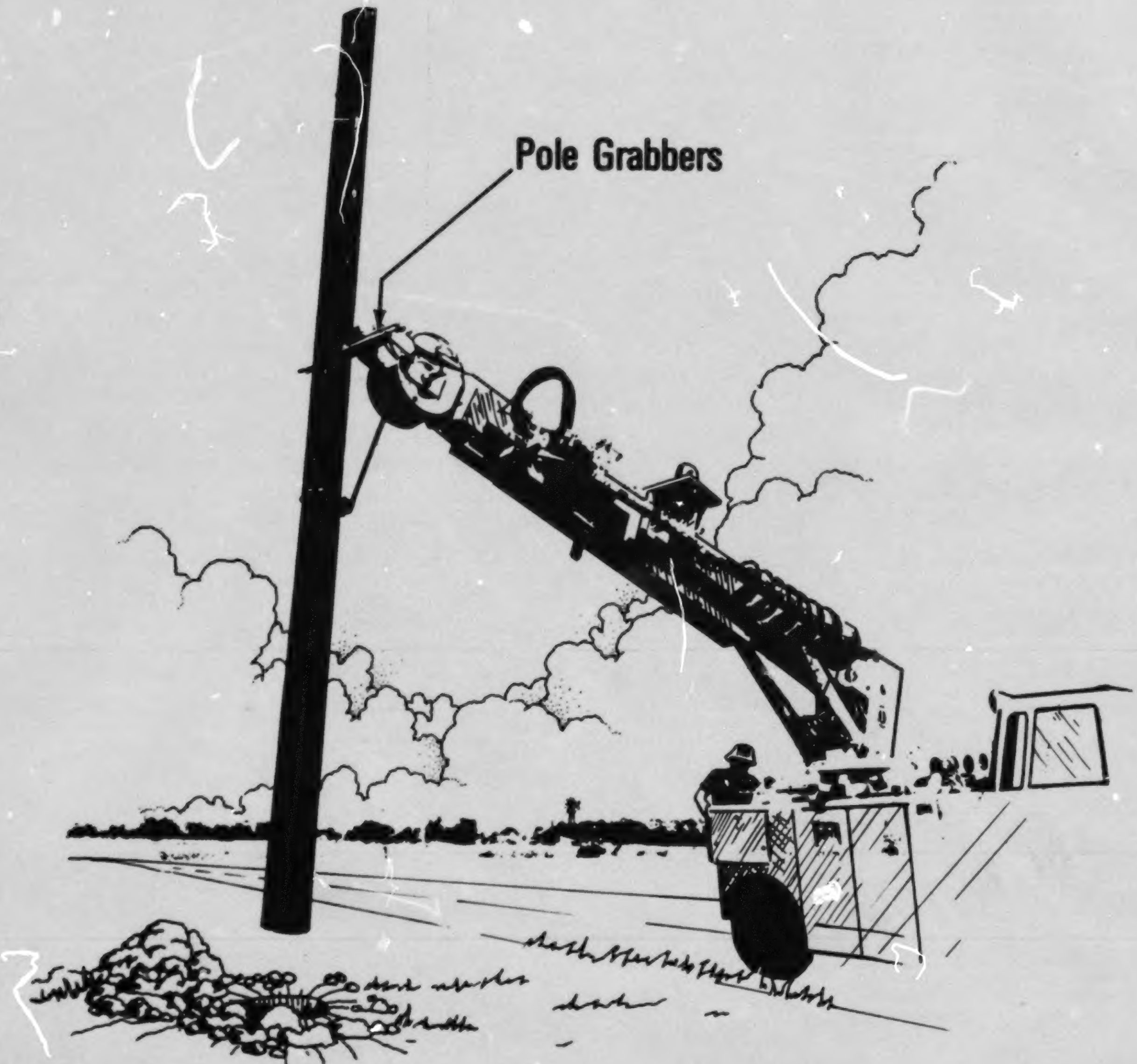
Setting Pole With Gin Pole



Setting Pole With A-Frame



Setting Pole With Boom



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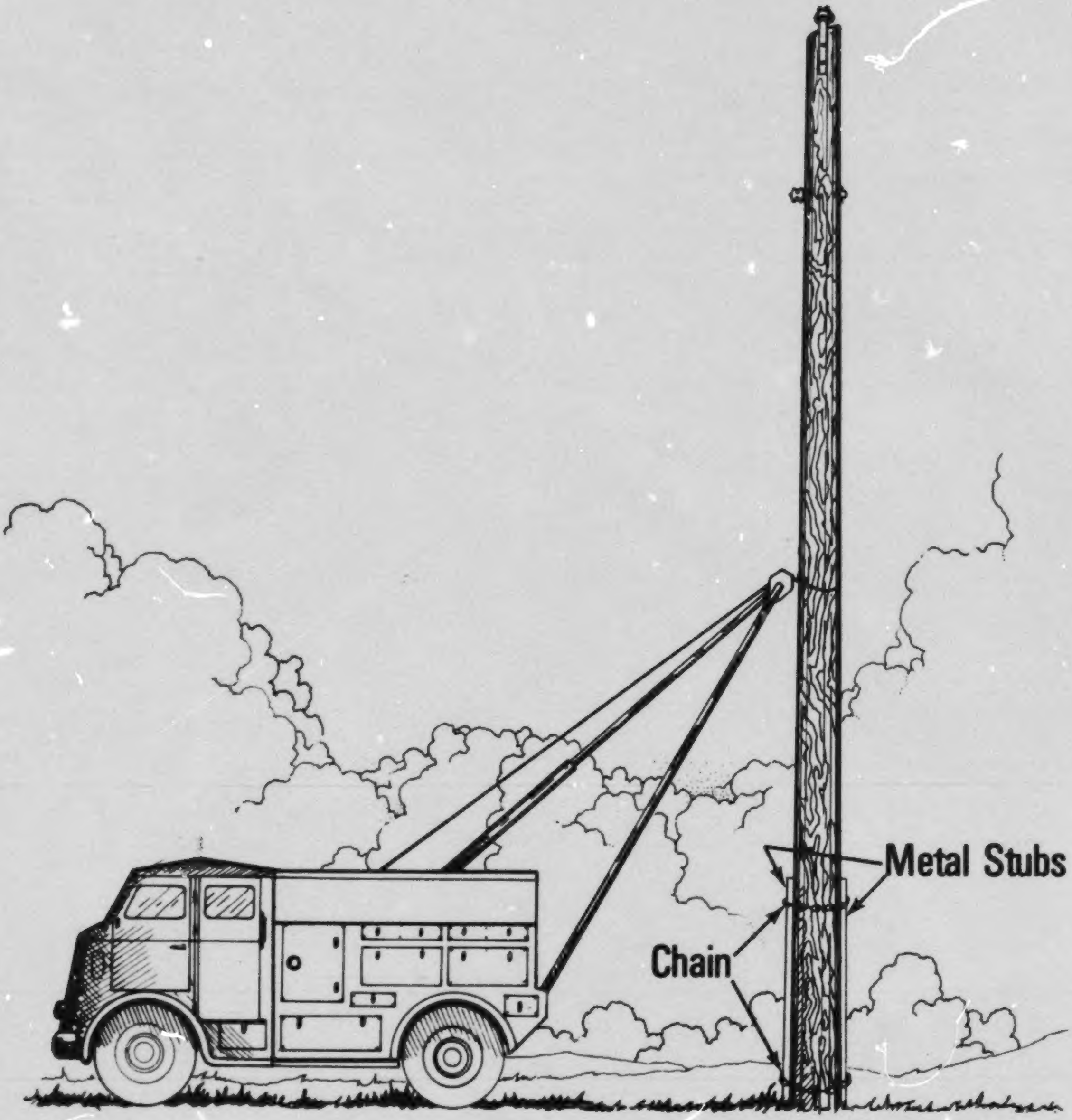
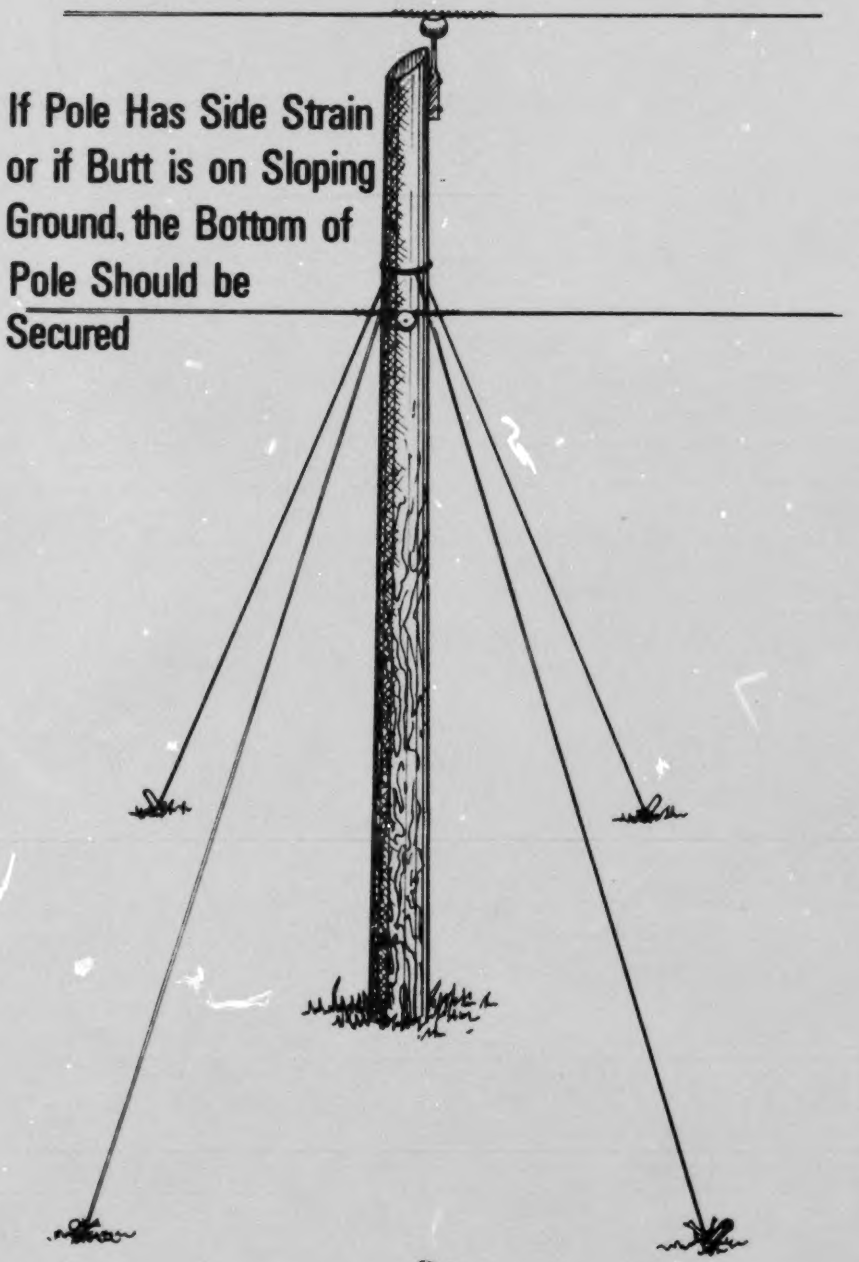
Supporting Unsafe Pole With A-Frame and Metal Stubs

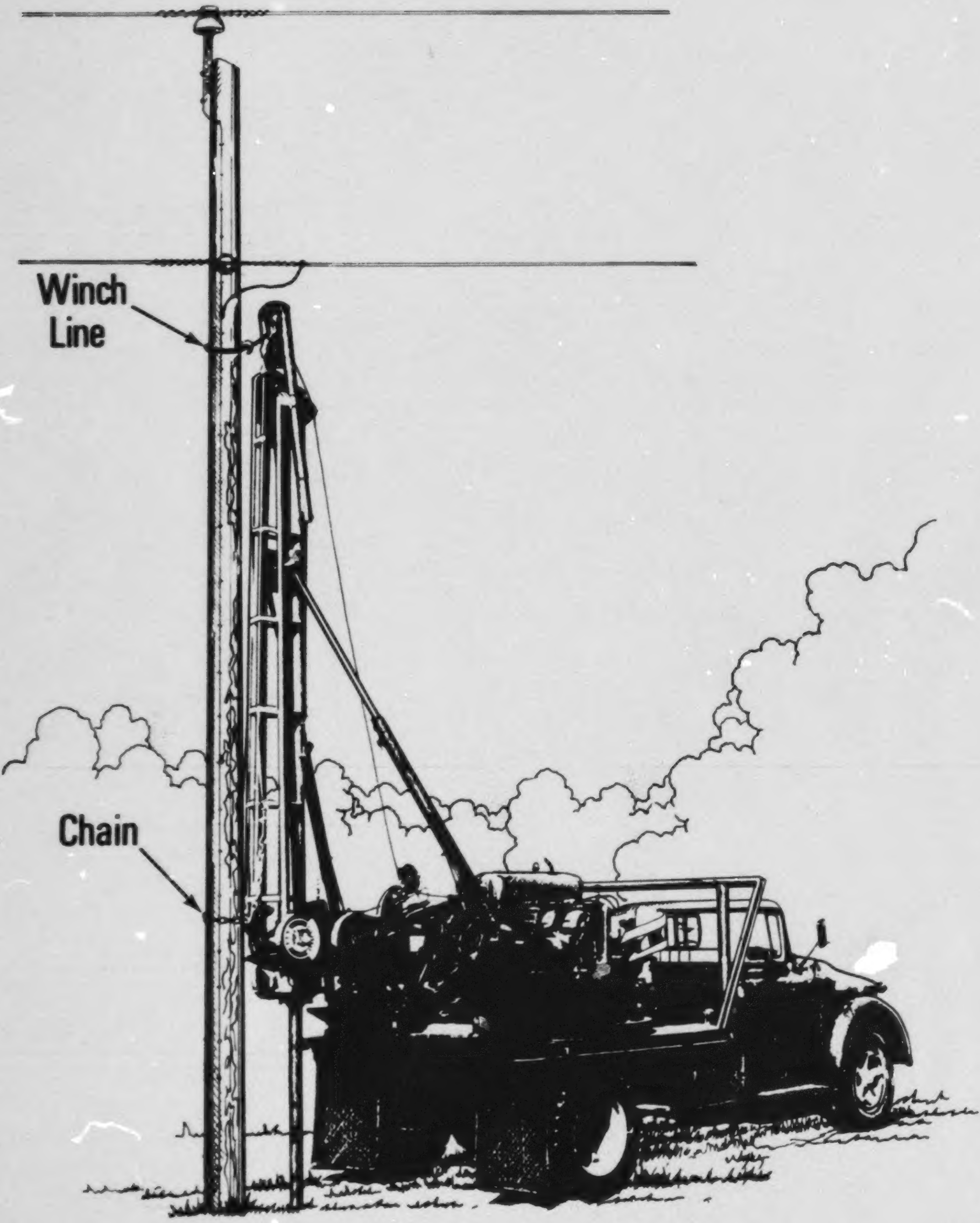


Supporting Unsafe Pole with Temporary Guys



Note: If Pole Has Side Strain or if Butt is on Sloping Ground, the Bottom of Pole Should be Secured

Supporting Pole with Digger Derrick



POLES
UNIT I

ASSIGNMENT SHEET #1-SELECT FROM A TABLE CLASSES OF POLES ACCORDING TO LENGTH AND CIRCUMFERENCE

Select the correct class of each of the following sizes and lengths of poles.

	Length of Pole	Circumference at Top	Circumference 6' from Butt	Class
1.	55'	22"	38"	____
2.	40'	18"	29"	____
3.	30'	26"	35"	____
4.	35'	22"	32"	____

Class	1	2	3	4	5	6	7	9	10
Minimum Circumference at Top (Inches)	27	25	23	21	19	17	15	15	12

Length of Pole (Feet)	Groundline Distance from Butt (Feet)	Minimum Circumference at 6 Feet from Butt (Inches)								
20	4	31.0	29.0	27.0	25.0	23.0	21.0	19.5	17.5	14.0
25	5	33.5	31.5	29.5	27.5	25.5	23.0	21.5	19.5	15.0
30	5 1/2	36.5	34.0	32.0	29.5	27.5	25.0	23.5	20.5	
35	6	39.0	36.5	34.0	31.5	29.0	27.0	25.0		
40	6	41.0	38.5	36.0	33.5	31.0	28.5	26.5		
45	6 1/2	43.0	40.5	37.5	35.0	32.5	30.0	28.0		
50	7	45.0	42.0	39.0	36.5	34.0	31.5	29.0		
55	7 1/2	46.5	43.5	40.5	38.0	35.0	32.5			
60	8	48.0	45.0	42.0	39.0	36.0	33.5			
65	8 1/2	49.5	46.5	43.5	40.5	37.5				
70	9	51.0	48.0	45.0	41.5	38.5				
75	9 1/2	52.5	49.0	46.0	43.0					
80	10	54.0	50.5	47.0	44.0					
85	10 1/2	55.0	51.5	48.0						
90	11	56.0	53.0	49.0						
95	11	57.0	54.0	50.0						
100	11	58.5	55.0	51.0						
105	12	59.5	56.0	52.0						
110	12	60.5	57.0	53.0						
115	12	61.5	58.0							
120	12	62.5	59.0							
125	12	63.5	59.5							

POLES
UNIT I

ASSIGNMENT SHEET #2-CALCULATE THE WEIGHT OF A LOAD OF POLES

Use the table below to calculate the total weight of the following classes and lengths of poles.

a. Two 25' class 6 poles = ____________________

b. Seven 35' class 5 poles = ____________________

c. One 30' class 7 pole = ____________________

d. Two 40' class 4 poles = ____________________

e. Total weight of all poles = ____________________

Estimated Weights for Southern Yellow Pine Poles

Length of Pole in Feet	Class						
	1	2	3	4	5	6	7
	Pounds						
25	990	811	674	573	491	422	344
30	1279	1082	921	784	660	550	454
35	1568	1343	1155	1004	862	743	646
40	1184	1623	1403	1219	1059	921	807
45	2223	1911	1664	1444	1274	1114	976
50	2585	2214	1925	1687	1494	1329	1169
55	2993	2567	2200	1934	1719	1563	
60	3451	2943	2512	2186	1953	1801	
65	4015	3341	2814	2457	2237		
70	4620	3781	3144	2732	2488		
75	5198	4235	3506	3021			
80	6400	5170	4240	3615			
85	7200	5745	4690				
90	8140	6405	5160				

POLES
UNIT I

ANSWERS TO ASSIGNMENT SHEETS

Assignment Sheet #1

1. 4
2. 6
3. 2
4. 4

Assignment Sheet #2

1. 844 lbs
2. 6034 lbs
3. 454 lbs
4. 2438 lbs
5. 9770 lbs

POLES
UNIT I

TEST

NAME ______________________________ SCORE ____________________

1. Match the terms on the right to the correct definitions.

______a. Solution forced into pole to increase its life expectancy

______b. Concave side; side of greatest curvature between groundline and top of pole

______c. Portion of pole one foot above and two feet below groundline

______d. Deviation from straightness in any five foot or shorter section which deviates more than one-half the diameter of the crooked section

______e. Deviation of a pole from straightness

______f. Separation of the wood along the grain

______g. Separation of the wood across the grain

______h. Lengthwise separation of the wood cells through the full diameter of the pole

______i. Separation along the grain between the rings of annual growth

1. Split
2. Sweep
3. Shake
4. Face
5. Preservative
6. Cross break
7. Groundline section
8. Short crook
9. Check

2. List two types of preservatives used on poles.

a. ____

b. ____

3. Match the code letters on the right to the type of preservative each represents.

______a. Creosote

______b. Creosote/coal tar solution

______c. Creosote/petroleum solution

______d. Copper naphthenate solution

______e. Penta (pentachlorophenal) solution

______f. Salt solution

1. N
2. X
3. S
4. P
5. C
6. T

4. Select from the table below the correct class of each of the following dimensions of poles.

Length of Pole	Circumference at Top	Circumference 6' from Butt	Class
a. 45	25	40.5	____
b. 25	20	26	____
c. 30	21	29.5	____
d. 35	24	35	____

Class	1	2	3	4	5	6	7	9	10
Minimum Circumference at Top (Inches)	27	25	23	21	19	17	15	15	12

Length of Pole (Feet)	Groundline Distance from Butt (Feet)	Minimum Circumference at 6 Feet from Butt (Inches)								
20	4	31.0	29.0	27.0	25.0	23.0	21.0	19.5	17.5	14.0
25	5	33.5	31.5	29.5	27.5	25.5	23.0	21.5	19.5	15.0
30	5 1/2	36.5	34.0	32.0	29.5	27.5	25.0	23.5	20.5	
35	6	39.0	36.5	34.0	31.5	29.0	27.0	25.0		
40	6	41.0	38.5	36.0	33.5	31.0	28.5	26.5		
45	6 1/2	43.0	40.5	37.5	35.0	32.5	30.0	28.0		
50	7	45.0	42.0	39.0	36.5	34.0	31.5	29.0		
55	7 1/2	46.5	43.5	40.5	38.0	35.0	32.5			
60	8	48.0	45.0	42.0	39.0	36.0	33.5			
65	8 1/2	49.5	46.5	43.5	40.5	37.5				
70	9	51.0	48.0	45.0	41.5	38.5				
75	9 1/2	52.5	49.0	46.0	43.0					
80	10	54.0	50.5	47.0	44.0					
85	10 1/2	55.0	51.5	48.0						
90	11	56.0	53.0	49.0						
95	11	57.0	54.0	50.0						
100	11	58.5	55.0	51.0						
105	12	59.5	56.0	52.0						
110	12	60.5	57.0	53.0						
115	12	61.5	58.0							
120	12	62.5	59.0							
125	12	63.5	59.5							

5. Select from the following list the precautions to observe when handling poles by placing an "X" in the blanks.

______a. Roll pole away from yourself when moving it

______b. Weigh pole before loading it

______c. Do not use cant hook or pole carrying hook in groundline section of pole

______d. Do not stand or walk on stacked poles

______e. Move pole with cant hook or bar by working from the ends of pole

______f. Use suitable equipment to lift pole

______g. Do not drag pole

______h. Attach sling or cable to pole by laying sling on ground and rolling pole onto sling

______i. Do not drop pole from vehicle or pole rack

6. Select the weight of the following lengths and classes of poles from the table below.

Length	Class	Weight
a. 40	6	______
b. 30	5	______
c. 35	4	______
d. 35	5	______
e. 30	7	______

Length of Pole in Feet	Class						
	1	2	3	4	5	6	7
	Pounds						
25	990	811	674	573	491	422	344
30	1279	1082	921	784	660	550	454
35	1568	1343	1155	1004	862	743	646
40	1884	1623	1403	1219	1059	921	807
45	2223	1911	1664	1444	1274	1114	976
50	2585	2214	1925	1687	1494	1329	1169
55	2993	2567	2200	1934	1719	1563	
60	3451	2943	2512	2186	1953	1801	
65	4015	3341	2814	2457	2237		
70	4620	3781	3144	2732	2488		
75	5198	4235	3506	3021			
80	6400	5170	4240	3615			
85	7200	5745	4690				
90	8140	6405	5160				

7. List four methods used to set poles.

a. ____________________

b. ____________________

c. ____________________

d. ____________________

8. State the correct procedure for checking pole before climbing.

a. ____________________

____

b. ____________________

____

c. ____________________

____

d. ____________________

____

9. Arrange in proper order the following steps for pole inspection. Place a "1" before the first step, a "2" before the second step, and so on.

_____a. Bore the pole with a 3/8" bit

_____b. Read and record brand information

_____c. Check for broken insulators

_____d. Sound the pole above ground

_____e. Sound the pole below ground

_____f. Excavate the pole to a depth of 18"

10. List three methods used to support unsafe poles for climbing.

a. ____________________

b. ____________________

c. ____________________

11. State the correct method for storing poles.

____

____

12. Calculate the weight of a load of poles.

(NOTE: If this has not been accomplished prior to the test, ask the instructor when it should be completed.)

POLES
UNIT I

ANSWERS TO TEST

1. Match the terms on the right to the correct definitions.

__5__ a. Solution forced into pole to increase its life expectancy

__4__ b. Concave side; side of greatest curvature between groundline and top of pole

__7__ c. Portion of pole one foot above and two feet below groundline

__8__ d. Deviation from straightness in any five foot or shorter section which deviates more than one-half the diameter of the crooked section

__2__ e. Deviation of a pole from straightness

__9__ f. Separation of the wood along the grain

__6__ g. Separation of the wood across the grain

__1__ h. Lengthwise separation of the wood cells through the full diameter of the pole

__3__ i. Separation along the grain between the rings of annual growth

1. Split
2. Sweep
3. Shake
4. Face
5. Preservative
6. Cross break
7. Groundline section
8. Short crook
9. Check

2. List two types of preservatives used on poles.

a. Oil-borne

b. Water-borne

3. Match the code letters on the right to the type of preservative each represents.

__5__ a. Creosote

__6__ b. Creosote/coal tar solution

__2__ c. Creosote/petroleum solution

__1__ d. Copper naphthenate solution

__4__ e. Penta (pentachlorophenal) solution

__3__ f. Salt solution

1. N
2. X
3. S
4. P
5. C
6. T

4. Select from the table below the correct class of each of the following dimensions of poles.

	Length of Pole	Circumference at Top	Circumference 6' from Butt	Class
a.	45	25	40.5	2
b.	25	20	26	5
c.	30	21	29.5	4
d.	35	24	35	3

Class	1	2	3	4	5	6	7	9	10
Minimum Circumference at Top (Inches)	27	25	23	21	19	17	15	15	12

Length of Pole (Feet)	Groundline Distance from Butt (Feet)	Minimum Circumference at 6 Feet from Butt (Inches)								
20	4	31.0	29.0	27.0	25.0	23.0	21.0	19.5	17.5	14.0
25	5	33.5	31.5	29.5	27.5	25.5	23.0	21.5	19.5	15.0
30	5 1/2	36.5	34.0	32.0	29.5	27.5	25.0	23.5	20.5	
35	6	39.0	36.5	34.0	31.5	29.0	27.0	25.0		
40	6	41.0	38.5	36.0	33.5	31.0	28.5	26.5		
45	6 1/2	43.0	40.5	37.5	35.0	32.5	30.0	28.0		
50	7	45.0	42.0	39.0	36.5	34.0	31.5	29.0		
55	7 1/2	46.5	43.5	40.5	38.0	35.0	32.5			
60	8	48.0	45.0	42.0	39.0	36.0	33.5			
65	8 1/2	49.5	46.5	43.5	40.5	37.5				
70	9	51.0	48.0	45.0	41.5	38.5				
75	9 1/2	52.5	49.0	46.0	43.0					
80	10	54.0	50.5	47.0	44.0					
85	10 1/2	55.0	51.5	48.0						
90	11	56.0	53.0	49.0						
95	11	57.0	54.0	50.0						
100	11	58.5	55.0	51.0						
105	12	59.5	56.0	52.0						
110	12	60.5	57.0	53.0						
115	12	61.5	58.0							
120	12	62.5	59.0							
125	12	63.5	59.5							

5. Select from the following list the precautions to observe when handling poles by placing an "X" in the blanks.

X a. Roll pole away from yourself when moving it

____ b. Weigh pole before loading it

X c. Do not use cant hook or pole carrying hook in groundline section of pole

X d. Do not stand or walk on stacked poles

X e. Move pole with cant hook or bar by working from the ends of pole

X f. Use suitable equipment to lift pole

X g. Do not drag pole

X h. Attach sling or cable to pole by laying sling on ground and rolling pole onto sling

X i. Do not drop pole from vehicle or pole rack

6. Select the weight of the following lengths and classes of poles from the table below.

	Length	Class	Weight
a.	40	6	921
b.	30	5	660
c.	35	4	1004
d.	35	5	862
e.	30	7	454

Length of Pole in Feet	Class 1	2	3	4	5	6	7
	Pounds						
25	990	811	674	573	491	422	344
30	1279	1082	921	784	660	550	454
35	1568	1343	1155	1004	862	743	646
40	1884	1623	1403	1219	1059	921	807
45	2223	1911	1664	1444	1274	1114	976
50	2585	2214	1925	1687	1494	1329	1169
55	2993	2567	2200	1934	1719	1563	
60	3451	2943	2512	2186	1953	1801	
65	4015	3341	2814	2457	2237		
70	4620	3781	3144	2732	2488		
75	5198	4235	3506	3021			
80	6400	5170	4240	3615			
85	7200	5745	4690				
90	8140	6405	5160				

7. List four methods used to set poles.

   a. Pike

   b. Gin pole

   c. A-frame

   d. Boom or digger derrick

8. State the correct procedure for checking pole before climbing.

   a. Check pole brand for proper depth

   b. Inspect pole visually for unauthorized attachments and cracked or broken insulators

   c. Sound pole with hammer

   d. Check for woodpecker holes and loose hardware

9. Arrange in proper order the following steps for pole inspection. Place a "1" before the first step, a "2" before the second step, and so on.

   6 a. Bore the pole with a 3/8" bit

   1 b. Read and record brand information

   2 c. Check for broken insulators

   3 d. Sound the pole above ground

   5 e. Sound the pole below ground

   4 f. Excavate the pole to a depth of 18"

10. List three methods used to support unsafe poles for climbing.

    (NOTE: Any three of the following methods are acceptable.)

    a. A-frame and metal stub

    b. Temporary guy

    c. Digger derrick

    d. Pole pike

    e. Pole stub

11. State the correct method for storing poles.

    Poles should be stored on racks with each layer separated or laid at a right angle to the layer below to allow for circulation of air

12. Calculate the weight of a load of poles.

    (NOTE: This activity will be evaluated to the satisfaction of the instructor.)

CONDUCTORS
UNIT II

UNIT OBJECTIVE

After completion of this unit, the student should be able to reel out conductor by various methods, join conductor, and determine conductor clearances. The student should be able to install an armor rod and various conductor ties. This knowledge will be evidenced through demonstration and by scoring 85 percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms commonly used with line conductors to the correct definitions.
2. List methods used to protect line conductor at supports.
3. Arrange in order the steps to follow when joining ACSR conductors.
4. Arrange in order the steps to follow when joining CWC conductors.
5. List classes of conductors.
6. List methods of reeling out conductor.
7. Identify various types of conductor ties.
8. Match types of conductors to their specific use.
9. State ground clearance for conductors in various locations.
10. Match minimum conductor clearances from building walls and roofs to conductor voltages.
11. Match current-carrying capacities of various ACSR conductors to the correct conductor size.
12. Match current-carrying capacities of various copperweld copper conductors to the correct conductor size.
13. Demonstrate the ability to:
    a. Install a preformed line tie on ACSR conductor on a de-energized circuit.
    b. Install a top groove conductor tie on a de-energized copper conductor.
    c. Install a preformed armor rod on ACSR conductor.
    d. Join ACSR conductor.

CONDUCTORS
UNIT II

SUGGESTED ACTIVITIES

I. Suggested activities for instructor:

   A. Provide student with objective sheet.

   B. Provide student with information and job sheets.

   C. Make transparencies.

   D. Discuss unit and specific objectives.

   E. Discuss information sheet.

   F. Demonstrate the use and adjustment of crimping tool.

   G. Show student ACSR and copperweld conductors of various sizes.

   H. Demonstrate and discuss the procedures outlined on the job sheets.

   I. Give test.

II. Unit references:

   A. Kurtz, Edwin B., and Shoemaker, Thomas M. *The Lineman's and Cableman's Handbook.* 5th ed. New York: McGraw-Hill Book Co., 1976.

   B. *National Electrical Code.* 1975 ed. Boston: National Fire Protection Association, 1974.

   C. U.S. Department of Commerce. *Safety Rules for the Installation and Maintenance of Electric Supply and Communication Lines.* National Bureau of Standards Handbook 81, pt 2. Washington, D.C.: U.S. Government Printing Office, 1961.

   D. Rural Electrification Administration. *Specifications and Drawings for 14.4/24.9 Kv Line Construction.* REA Form 803. rev. Washington, D.C.: U.S. Department of Agriculture, September 1969.

2

CONDUCTORS
UNIT II

INFORMATION SHEET

I. Terms and definitions

  A. Copperweld--Steel core conductor with a welded coating of copper

  B. ACSR--Aluminum conductor steel reinforced

  C. CWC--Copperweld copper conductor

  D. AWG--American wire gauge

  E. Anneal--To heat and let cool slowly to soften

  F. Hard-drawn wire--Wire which has been tempered for strength

  G. Soft-drawn wire--Annealed wire

  H. Alumoweld wire--Steel wire with a welded coating of aluminum

  I. Circular mil--Area of a circle which is one-thousandth of an inch in diameter

  J. mcm--One thousand circular mils

  K. Static wire--Steel conductor strung above transmission lines for a ground wire

  L. Weatherproofing--Coating of neoprene or of braided cotton saturated with an asphalt compound

  M. Armor tape--Flat aluminum ribbon one-fourth inch wide

  N. Kilovolt (kV)--Unit of measure of electromotive force equal to one thousand volts

  O. Crimping tool--Tool used to join conductor with a sleeve

II. Methods to protect line conductor at supports (Transparency 1)

  A. Preformed armor rod

  B. Clip type armor rod

  C. Preformed conductor tie

  D. Armor tape

INFORMATION SHEET

III. Steps to follow when joining a ACSR conductor
   - A. Select proper sleeve for wire size
   - B. Select proper crimping tool
   - C. Remove aluminum strands from steel core the distance recommended by splice manufacturer
   - D. Clean conductor with conductor brush
   - E. Slide conductor sleeve onto conductor
   - F. Install and crimp core sleeve

     (NOTE: Some ACSR sleeves may not require a core sleeve.)
   - G. Slide center of conductor sleeve to center of core sleeve
   - H. Crimp conductor sleeve from center of sleeve outward

IV. Steps to follow when joining a CWC conductor
   - A. Select proper sleeve for wire size
   - B. Select proper crimping tool
   - C. Clean conductor with conductor brush
   - D. Install sleeve and crimp from center of sleeve outward

V. Classes of conductors
   - A. Solid
   - B. Stranded

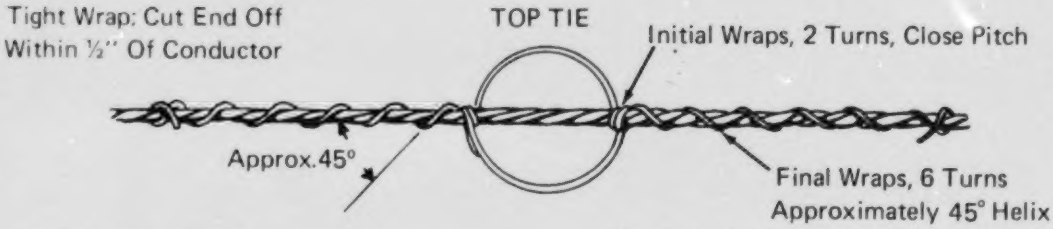
VI. Methods of reeling out conductor
   - A. Tie off end of conductor and move reel along line route
   - B. Set up reel and pull conductor through structures or along the ground
   - C. Set up anchored reel with braking system and pull conductor under controlled tension through structures

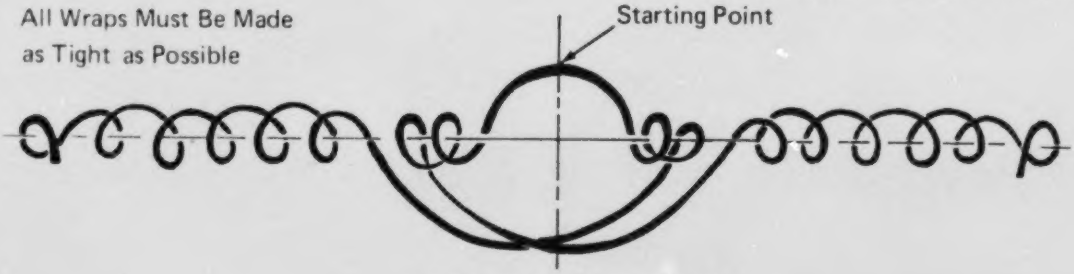
     (NOTE: When pulling conductor from stationary reel, do not drag conductor over sharp objects or allow damage to insulated conductor.)

INFORMATION SHEET

VII. Conductor ties

A. Copper conductor top groove

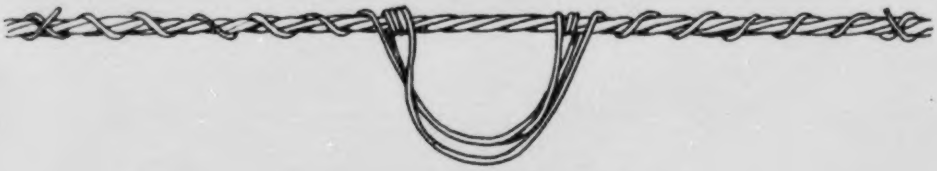


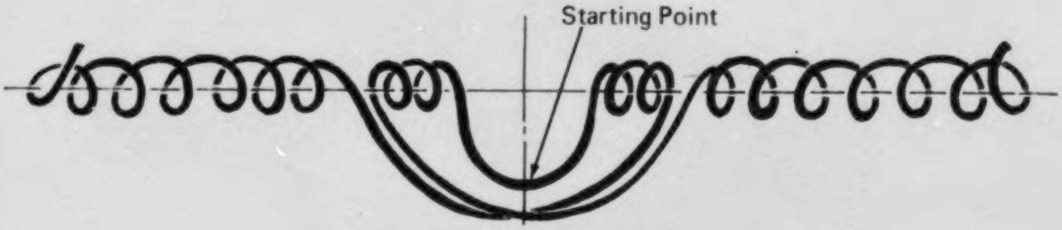


TOP TIE DETAIL VIEW

B. Copper conductor side groove

(NOTE: Tie wire must be annealed copper.)

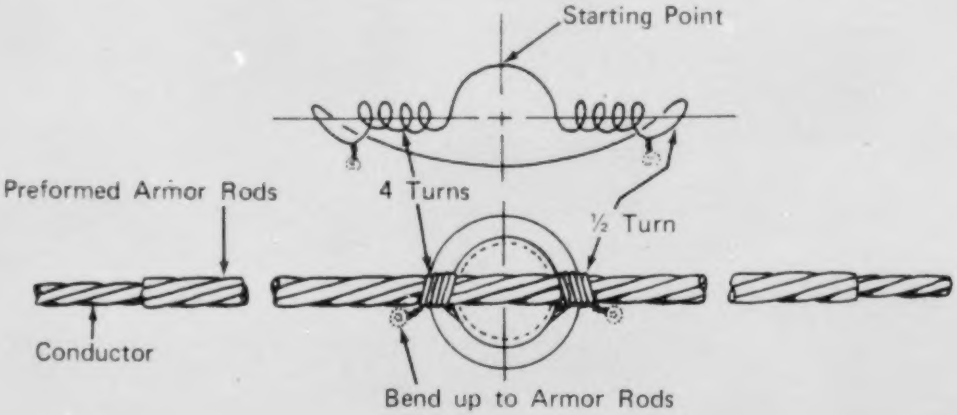




SIDE TIE DETAIL VIEW

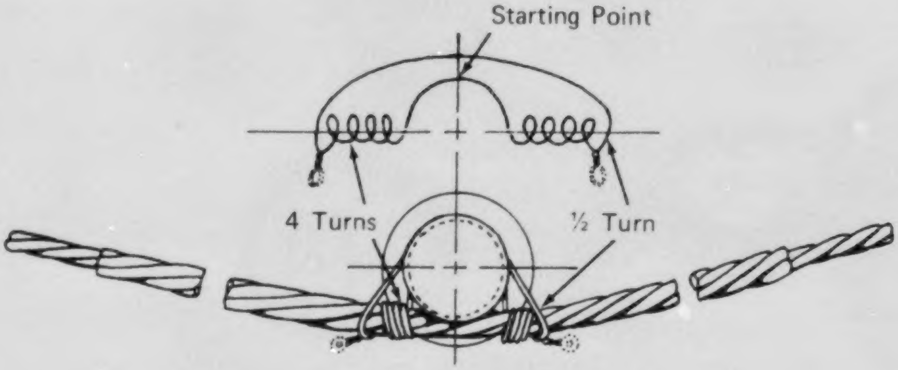
INFORMATION SHEET

C. Copper conductor top groove hot line tie



D. Copper conductor side groove hot line tie

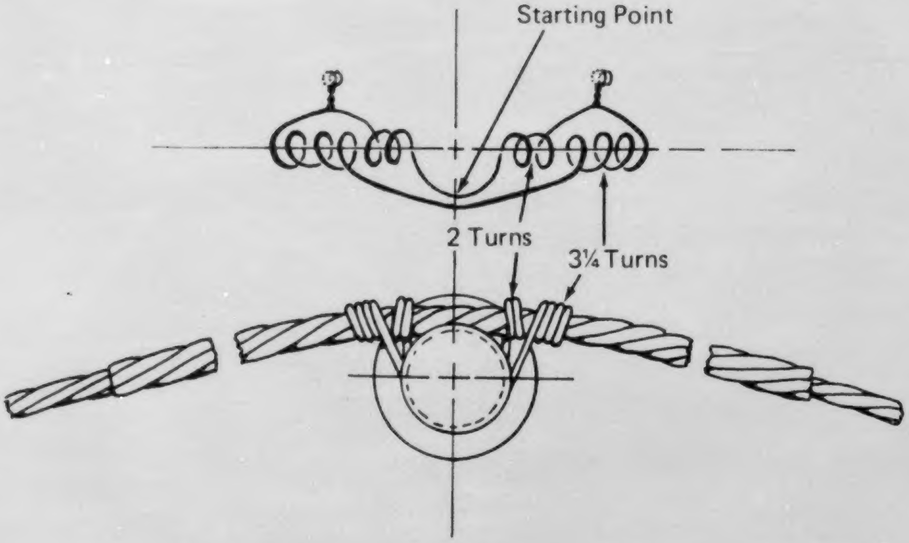
1.



(NOTE: Tie wire assembly should be as tight as can be wrapped by hand. The ends should be twisted with hot line tools. Twist left-hand ends clockwise; twist right-hand ends counterclockwise.)

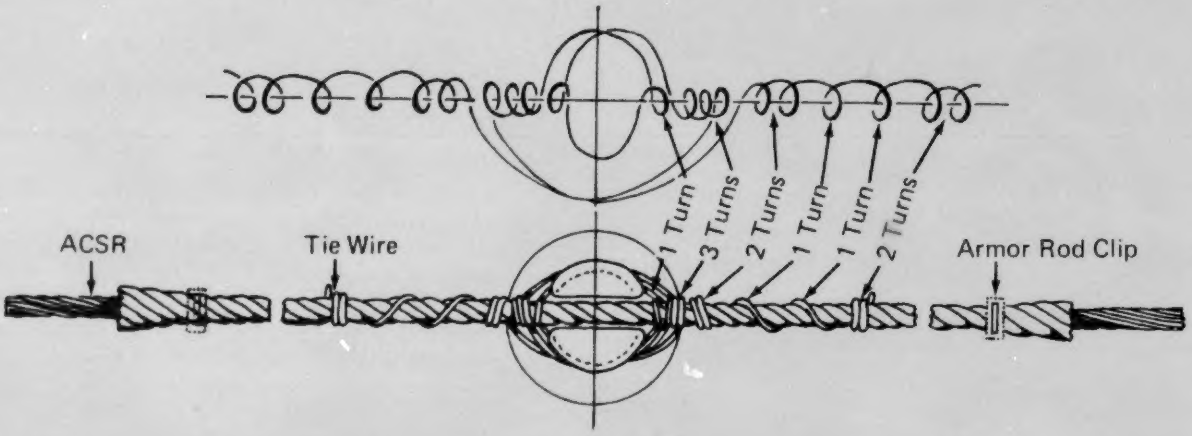
INFORMATION SHEET

2.



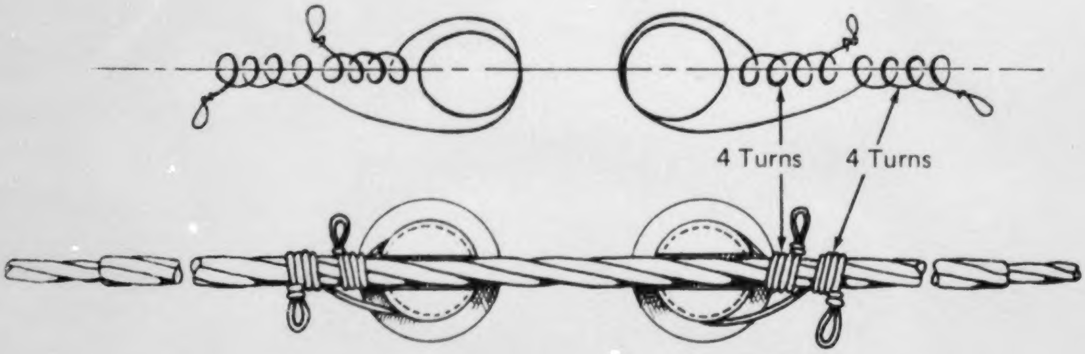
(NOTE: Tie wire assembly should be as tight as can be wrapped by hand. Ends should be twisted with pliers or hot line tools. Twist left-hand ends clockwise; twist right-hand ends counterclockwise.)

E. ACSR conductor top groove double tie

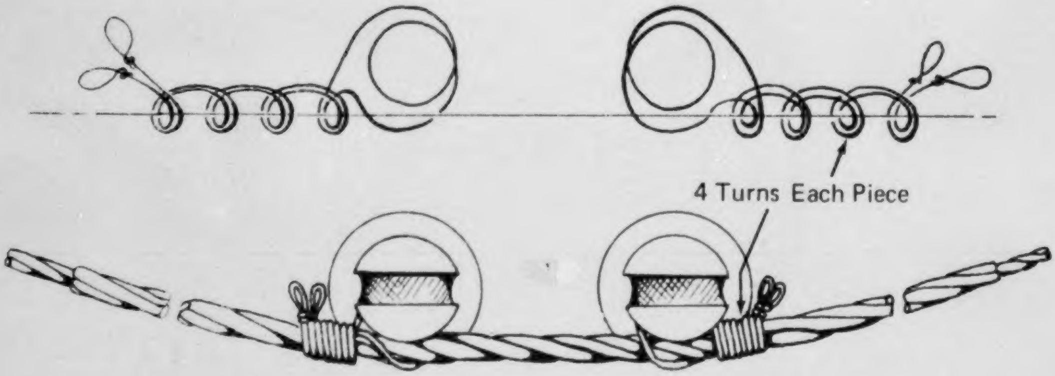


INFORMATION SHEET

F. ACSR conductor top groove double insulator hot line tie

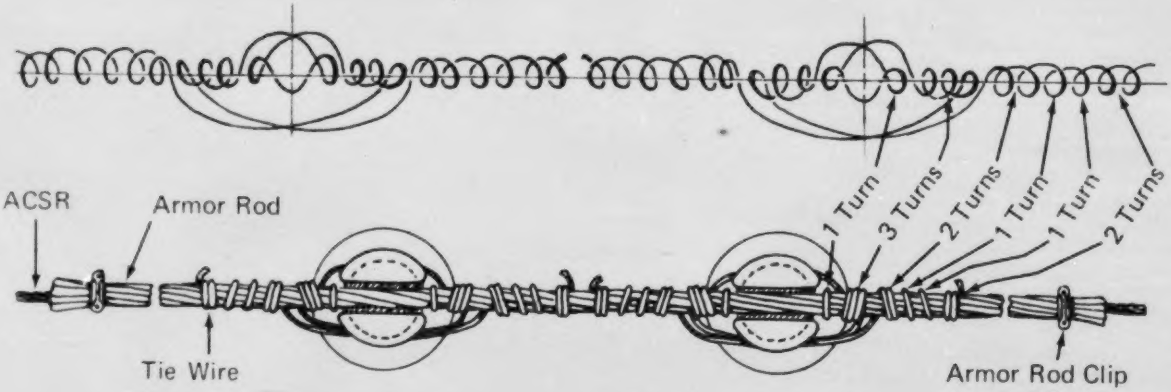


G. ACSR conductor side groove double insulator hot line tie



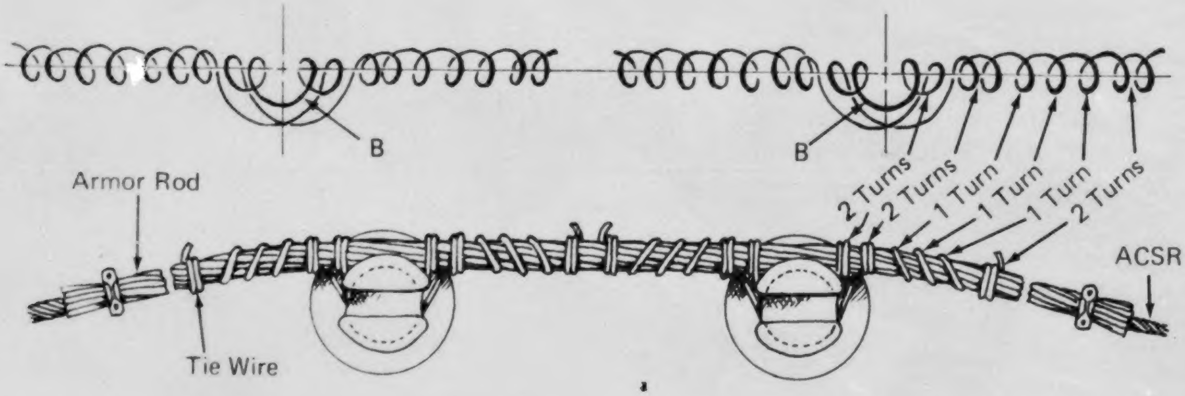
INFORMATION SHEET

H. ACSR conductor top groove double insulator double tie



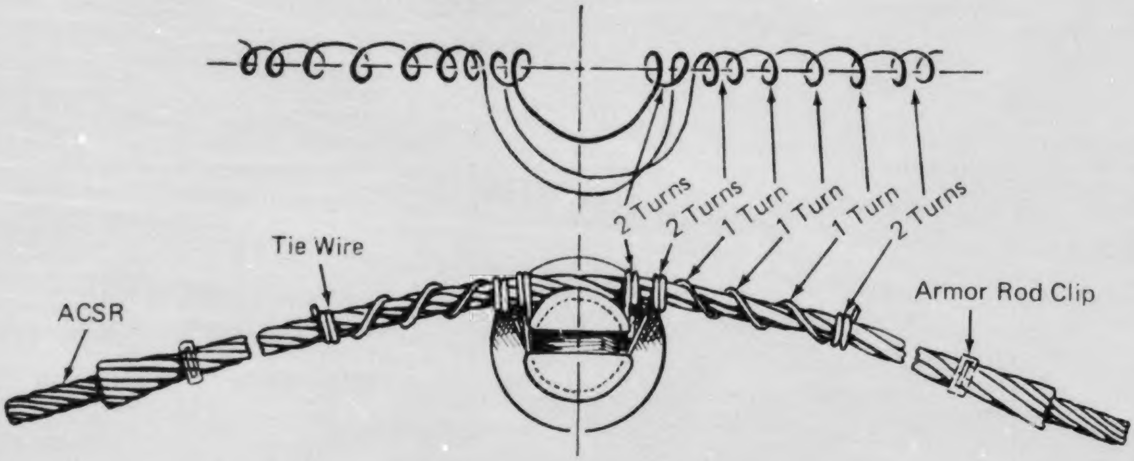
I. ACSR conductor side groove double insulator double tie

(NOTE: In making ties, start with middle of tie wire at position marked "B". To complete tie, cinch up the last two turns at each end with pliers until tie wire is tight. Use the flat face of the pliers against the armor rods.)

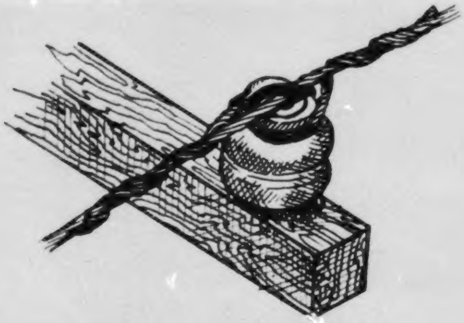


INFORMATION SHEET

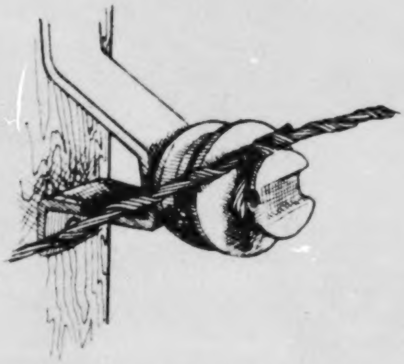
J. ACSR conductor side groove tie



K. ACSR conductor top groove preformed tie



L. ACSR conductor side groove preformed tie



INFORMATION SHEET

VIII. Uses of various types of conductors

- A. ACSR--Primary and secondary
- B. Copperweld copper--Primary and secondary
- C. Hard-drawn copper--Primary and secondary
- D. Soft-drawn copper--Pole ground, tie wire, and jumper
- E. Weatherproof--Secondary and service

IX. Conductor clearance from ground or roof for 750 volts or less (Transparency 2)

- A. 13 feet over sidewalks or platforms from which the conductor may be reached
- B. 13 feet over residential driveways and commercial areas not subject to truck traffic
- C. 16 feet over commercial parking lots and agricultural areas not subject to truck traffic
- D. 16 feet over public streets, alleys, and driveways other than residential which are subject to truck traffic and over roofs accessible to vehicular traffic

X. Minimum clearances (Transparency 3)

- A. Over roofs
  - 1. 17 feet for 15,000 to 50,000 volts
  - 2. 15 feet for 8,700 to 15,000 volts
  - 3. 15 feet for 750 to 8,700 volts
  - 4. 15 feet for 750 volts or less
- B. Away from walls of building
  - 1. 10 feet for 15,000 to 50,000 volts
  - 2. 8 feet for 8,700 to 15,000 volts or less
  - 3. 5 feet for 750 to 8,700 volts
  - 4. 5 feet for 750 volts or less

(NOTE: Clearance over roofs and from side walls for voltage above 50,000 is 10 feet plus 0.4 inches for each kV over 50,000.)

INFORMATION SHEET

XI. Conductor sizes and approximate current-carrying capacities for ACSR conductors

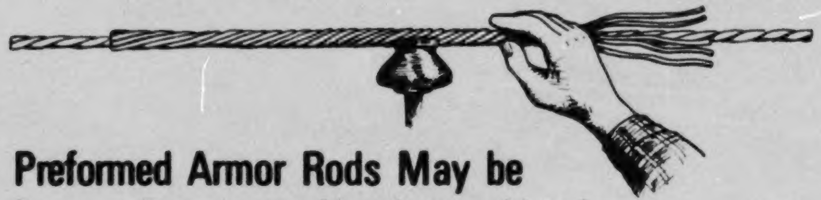
Conductor Size	Current Carrying Capacity (Amperes)
#4	140
#2	180
#1	200
#1/0	230
#2/0	270
#3/0	300
#4/0	340
266.8 mcm	460
300 mcm	490
336.4 mcm	530
397.5 mcm	590
477 mcm	670
556.5 mcm	730
605 mcm	760
636 mcm	780

XII. Copperweld copper conductor sizes and approximate current-carrying capacities

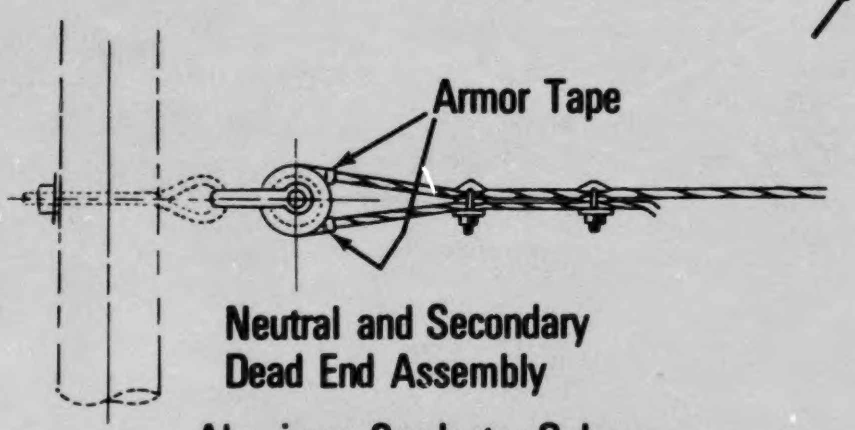
Conductor Size	Current-Carrying Capacity (In Amperes)
8A	100
6A	140
4A	180
2F	230
1/0F	310
3/0F	410

Methods To Protect Line Conductor At Supports

Preformed Armor Rod



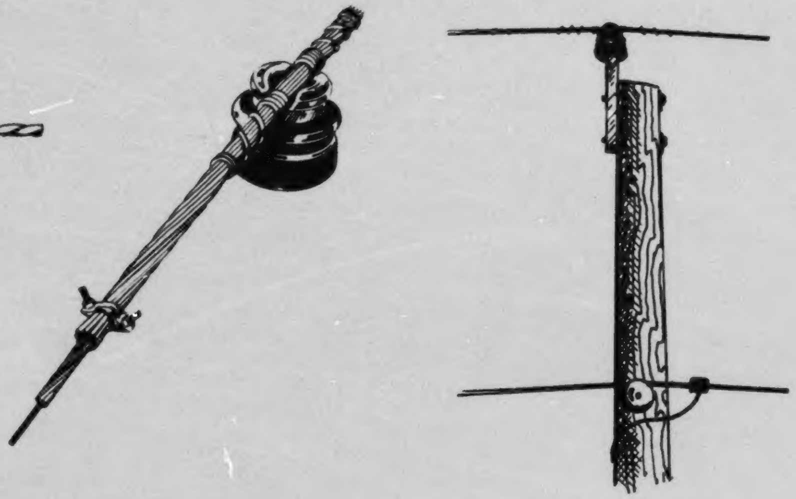
Preformed Armor Rods May be Copper, Bronze, or Aluminum. Aluminum Rods are Used Only on Aluminum Conductor



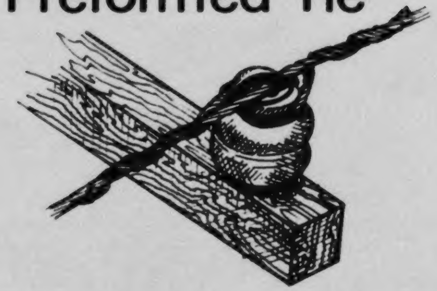
Neutral and Secondary Dead End Assembly

Aluminum Conductor Only

Clip Type Armor Rod

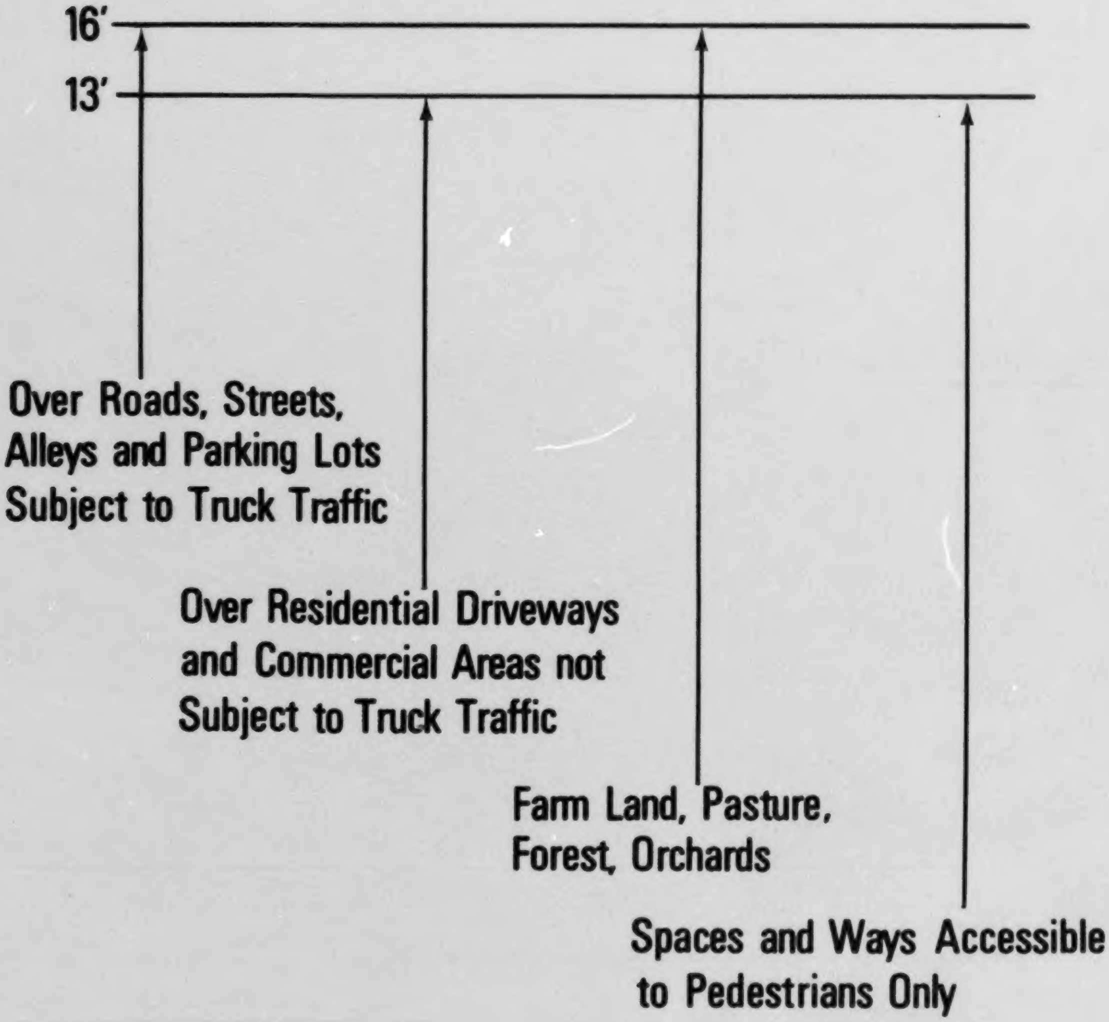


Preformed Tie

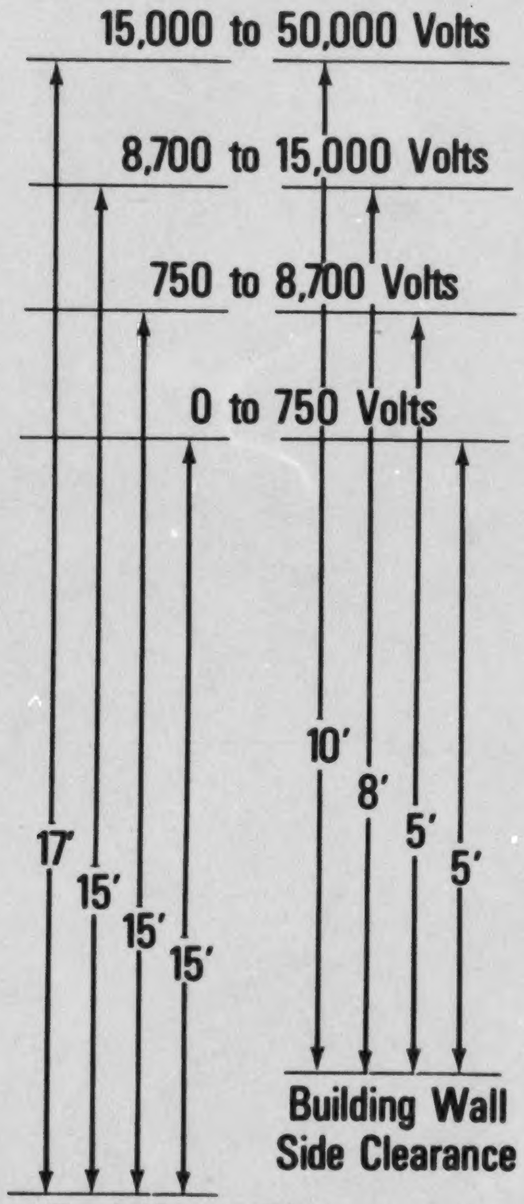


Clearance from Ground for Conductors

750 Volts or Less


16′
13′
Over Roads, Streets, Alleys and Parking Lots Subject to Truck Traffic
Over Residential Driveways and Commercial Areas not Subject to Truck Traffic
Farm Land, Pasture, Forest, Orchards
Spaces and Ways Accessible to Pedestrians Only

Minimum Clearance Over Roofs and from Building Walls



420

CONDUCTORS
UNIT II

JOB SHEET #1--INSTALL A PREFORMED LINE TIE ON ACSR CONDUCTOR ON A DE-ENERGIZED CIRCUIT

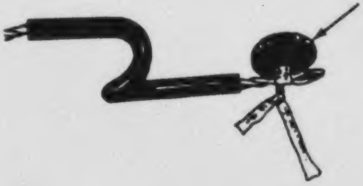
I. Tools and equipment

A. ACSR conductor fixed in a taut position

B. Line insulator with support

C. Preformed line tie for size of ACSR conductor being used (Figure 1)

FIGURE 1

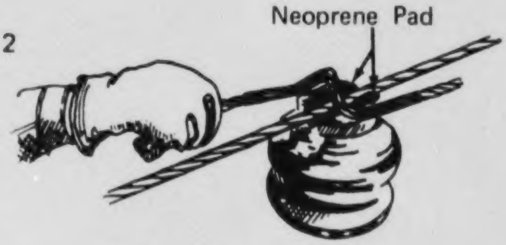


II. Procedure

A. Place neoprene pad under conductor in center of top groove of insulator (Figure 2)

B. Place the center of the tie across the top of insulator with the end of the tie parallel to the conductor (Figure 2)

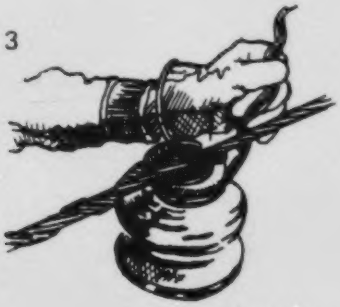
FIGURE 2



JOB SHEET #1

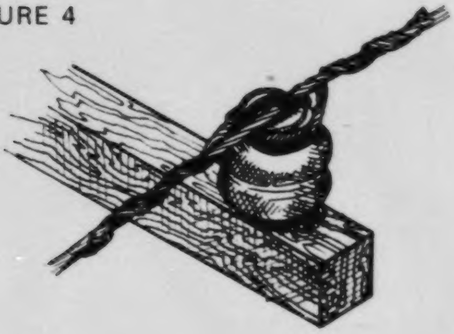
C. Rotate the tie around the insulator until one end of the tie is around the neck of the insulator and wrapped onto the conductor (Figure 3)

FIGURE 3



D. Complete the tie by wrapping both ends of the tie onto the conductor and snapping the ends into place (Figure 4)

FIGURE 4



CONDUCTORS
UNIT II

JOB SHEET #2--INSTALL A TOP GROOVE CONDUCTOR TIE ON A DE-ENERGIZED COPPER CONDUCTOR

I. Tools and equipment

   A. Copper conductor fixed in a taut position

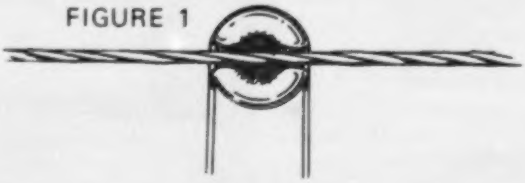
   B. Line insulator with support

   C. Length of annealed copper tie wire

II. Procedure

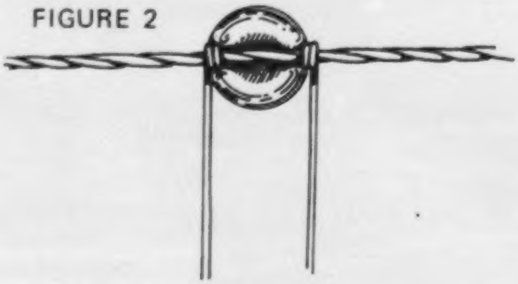
   A. Bend tie wire of proper size and length around neck of insulator under the conductor (Figure 1)

FIGURE 1



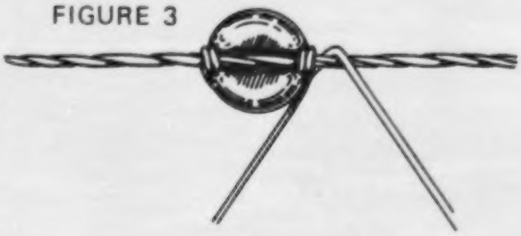
   B. Hold tie wire tightly around insulator neck and make two close, tight wraps around conductor (Figure 2)

FIGURE 2



   C. Cross ends of tie wire around the insulator and under the conductor (Figure 3)

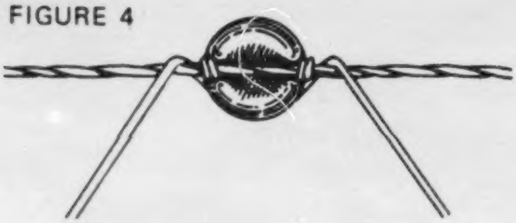
FIGURE 3



JOB SHEET #2

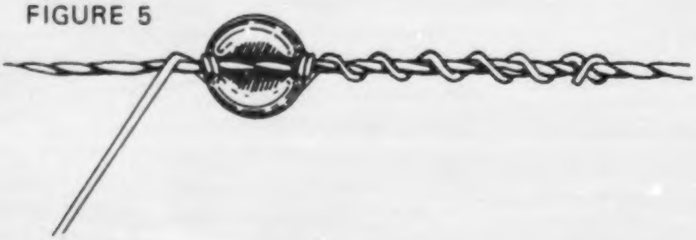
D. Wrap each end of tie wire onto conductor snugly at a 45° angle (Figure 4)

FIGURE 4



E. Wrap six wraps at 45° angle on each side of insulator (Figure 5)

FIGURE 5



CONDUCTORS
UNIT II

JOB SHEET #3--INSTALL A PREFORMED ARMOR ROD ON ACSR CONDUCTOR

I. Tools and equipment

   A. ACSR conductor fixed in a taut position

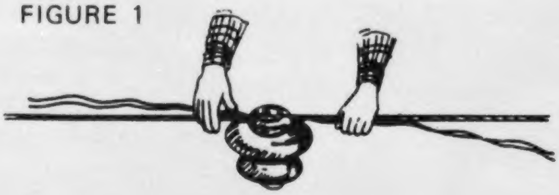
   B. Line insulator with support

   C. Armor rod sized to the ACSR conductor being used

II. Procedure

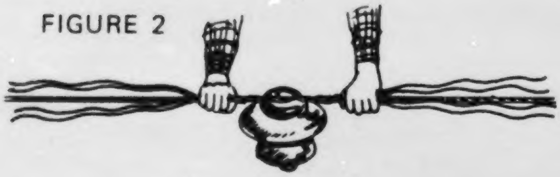
   A. Place two strands of armor rod around conductor with center of armor rod at the center of the insulator (Figure 1)

FIGURE 1



   B. Place two or three strands at a time around the conductor until the full set of strands are in place (Figure 2)

FIGURE 2

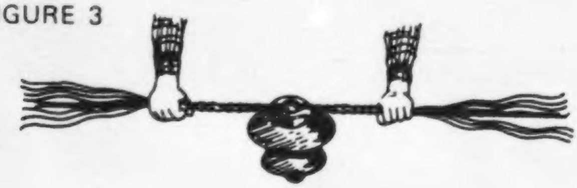


JOB SHEET #3

C. Rotate your hands around the armor rod with a rolling motion (Figure 3)

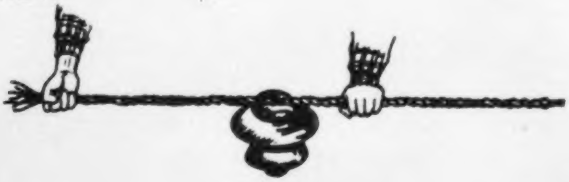
(NOTE: Roll one hand away from yourself and the other hand toward yourself, letting the armor rod wrap onto the conductor from the center outward.)

FIGURE 3



D. Continue rotating the rods until the full length has rolled onto the conductor and the ends are snapped into place (Figure 4)

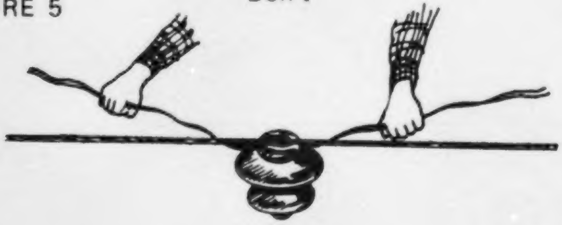
FIGURE 4



(CAUTION: Do not force strands into place. Preformed rods cannot be installed properly if any of the strands are bent. See Figure 5.)

FIGURE 5

Don't



CONDUCTORS
UNIT II

JOB SHEET #4--JOIN ACSR CONDUCTOR

I. Tools and equipment

  A. Length of ACSR conductor

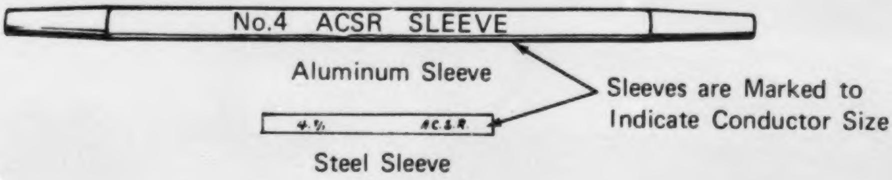
  B. Hammer

  C. Manual or hydraulic crimping tool

  D. Conductor brush

  E. Sleeve sized to conductor being used (Figure 1)

FIGURE 1

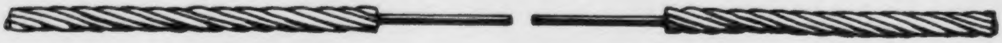


II. Procedure

  A. Select proper crimping tool according to recommendations of sleeve manufacturer

  B. Remove aluminum strands from steel core the distance recommended by splice manufacturer (Figure 2)

FIGURE 2



ACSR Ready for Splicing

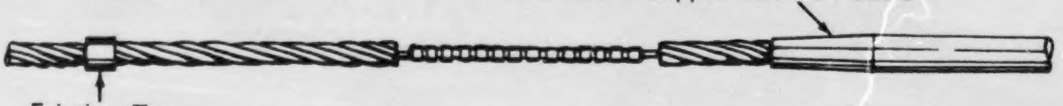
JOB SHEET #4

C. Clean conductor with conductor brush

D. Slide conductor sleeve onto conductor

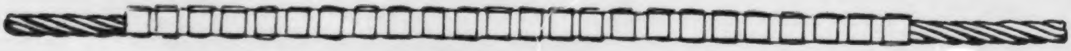
E. Install and crimp core sleeve (Figure 3)

FIGURE 3


Aluminum Sleeve Slipped Back on Cable
Friction Tape
Steel Sleeve Pressed on Steel Core

F. Slide center of conductor sleeve to center of core sleeve and crimp from the center toward the ends (Figure 4)

FIGURE 4



Completed Splice

G. Straighten splice by hammering carefully against a suitable block

CONDUCTORS
UNIT II

TEST

NAME ______________________________ SCORE ____________________

1. Match the terms on the right to the correct definitions.

_____a. Aluminum conductor steel reinforced

_____b. Copperweld copper conductor

_____c. American wire gauge

_____d. To heat and let cool slowly to soften

_____e. Annealed wire

_____f. Steel wire with a welded coating of aluminum

_____g. Wire which has been tempered for strength

_____h. Area of a circle which is one-thousandth of an inch in diameter

_____i. One thousand circular mils

_____j. Steel conductor strung above transmission lines for a ground wire

_____k. Coating of neoprene or of braided cotton saturated with an asphalt compound

_____l. Unit of measure of electromotive force equal to one thousand volts

_____m. Steel core conductor with a welded coating of copper

_____n. Flat aluminum ribbon one-fourth inch wide

_____o. Tool used to join conductor with a sleeve

1. Armor tape
2. mcm
3. Circular mil
4. Static wire
5. Soft-drawn wire
6. Anneal
7. Copperweld
8. AWG
9. Kilovolt (kV)
10. ACSR
11. Weatherproofing
12. CWC
13. Hard-drawn wire
14. Crimping tool
15. Alumoweld wire

2. List three methods used to protect line conductor at supports.

a. ______________________________

b. ______________________________

c. ______________________________

3. Arrange in order the steps to follow when joining an ACSR conductor. Place a "1" before the first step, a "2" before the second step, and so on.

_____a. Slide conductor sleeve onto conductor

_____b. Install and crimp core sleeve

_____c. Select proper crimping tool

_____d. Clean conductor with conductor brush

_____e. Crimp conductor sleeve from center of sleeve outward

_____f. Remove aluminum strands from steel core the distance recommended by splice manufacturer

_____g. Slide center of conductor sleeve to center of core sleeve

_____h. Select proper sleeve for wire size

4. Arrange in order the steps to follow when joining a CWC conductor. Place a "1" before the first step, a "2" before the second step, and so on.

_____a. Install sleeve and crimp from center of sleeve outward

_____b. Clean conductor with conductor brush

_____c. Select proper crimping tool

_____d. Select proper sleeve for wire size

5. List two classes of conductors.

a. ______________________________

b. ______________________________

6. List three methods of reeling out conductor.

a. ______________________________

____

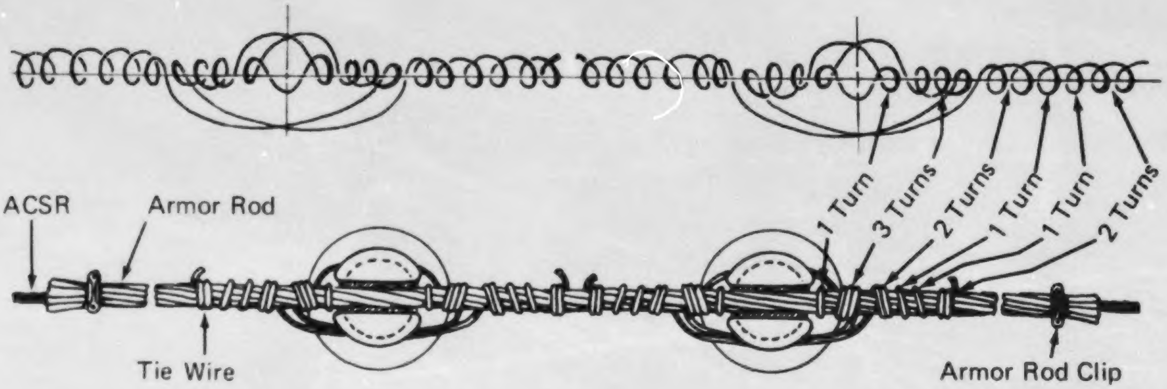
b. ______________________________

____

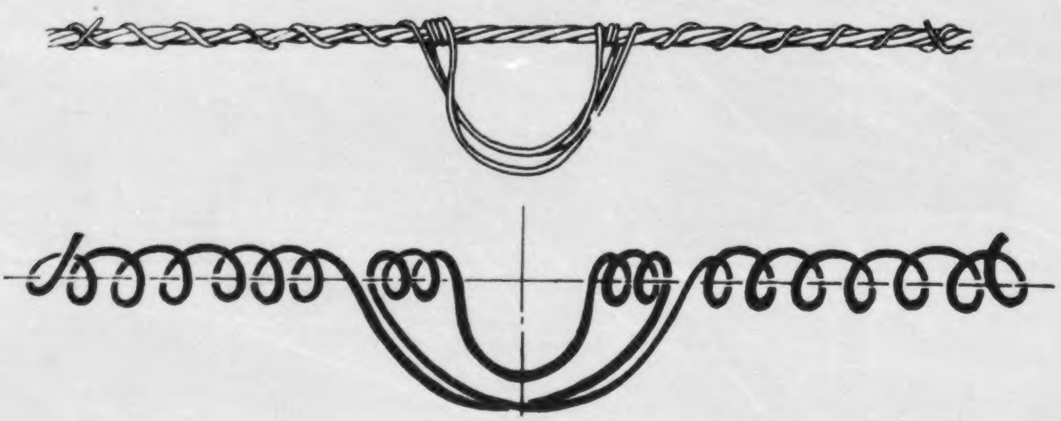
c. ______________________________

____

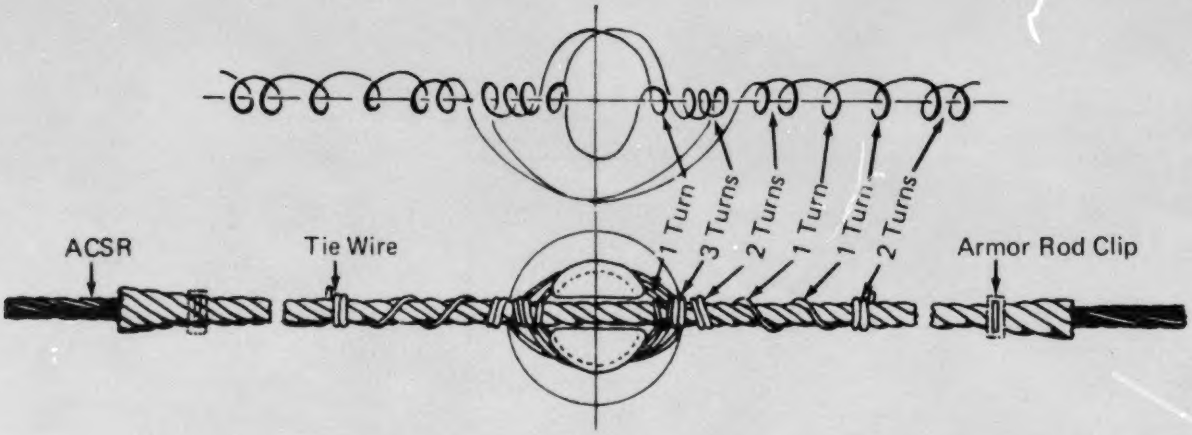
7. Identify the following conductor ties.



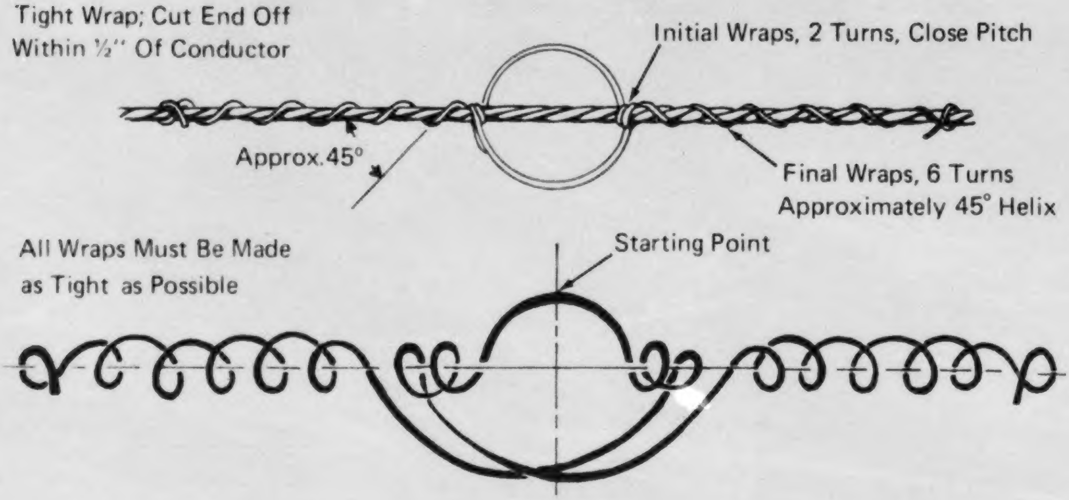
a. ______________________________



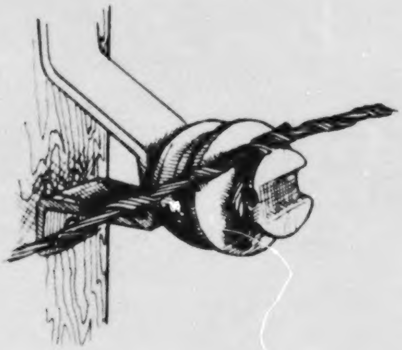
b. ______________________________


1 Turn
3 Turns
2 Turns
1 Turn
1 Turn
2 Turns
ACSR
Tie Wire
Armor Rod Clip

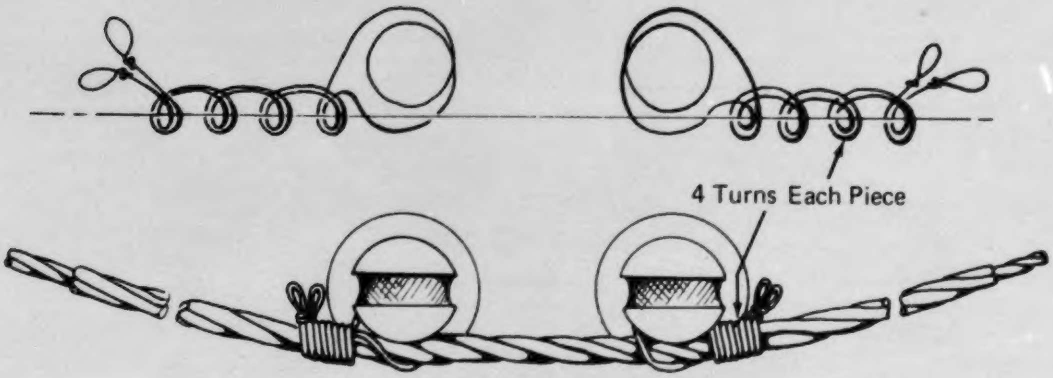
c. ____


Tight Wrap; Cut End Off
Within ½" Of Conductor
Initial Wraps, 2 Turns, Close Pitch
Approx.45°
Final Wraps, 6 Turns
Approximately 45° Helix
All Wraps Must Be Made
as Tight as Possible
Starting Point

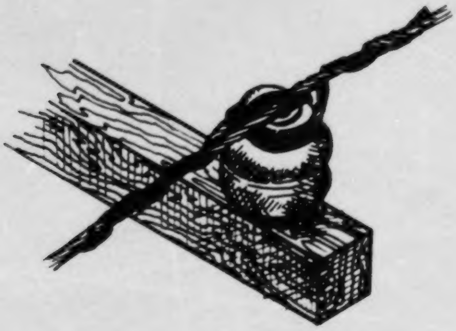
d. ____



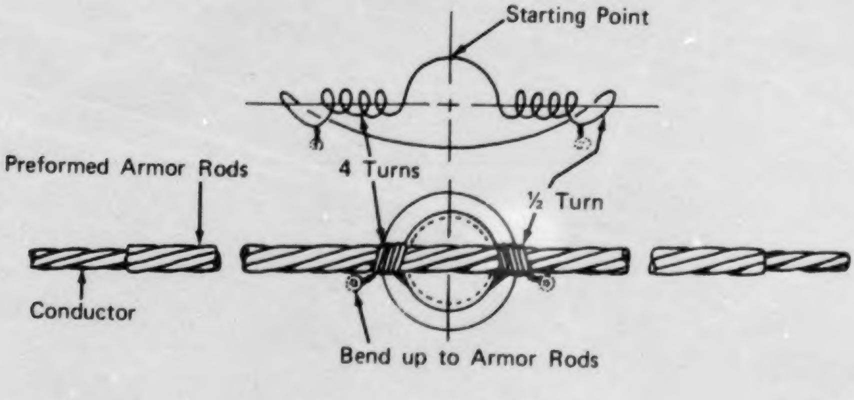
e. ____


4 Turns Each Piece

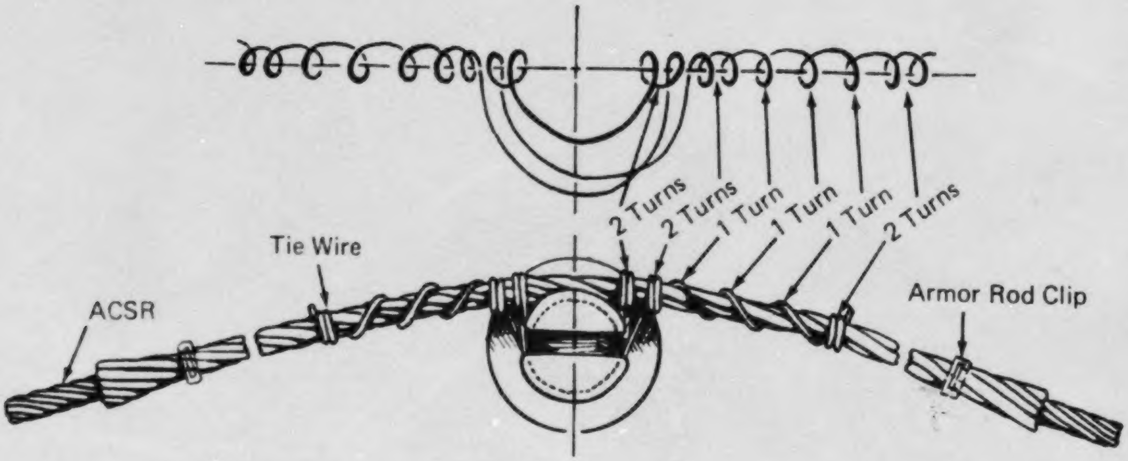
f. ______________________________



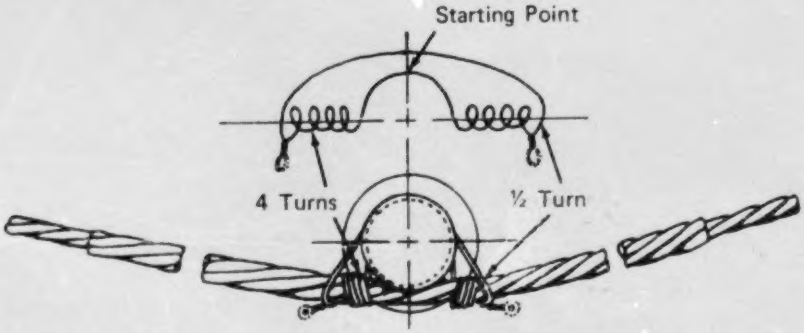
g. ______________________________


Starting Point
Preformed Armor Rods
4 Turns
½ Turn
Conductor
Bend up to Armor Rods

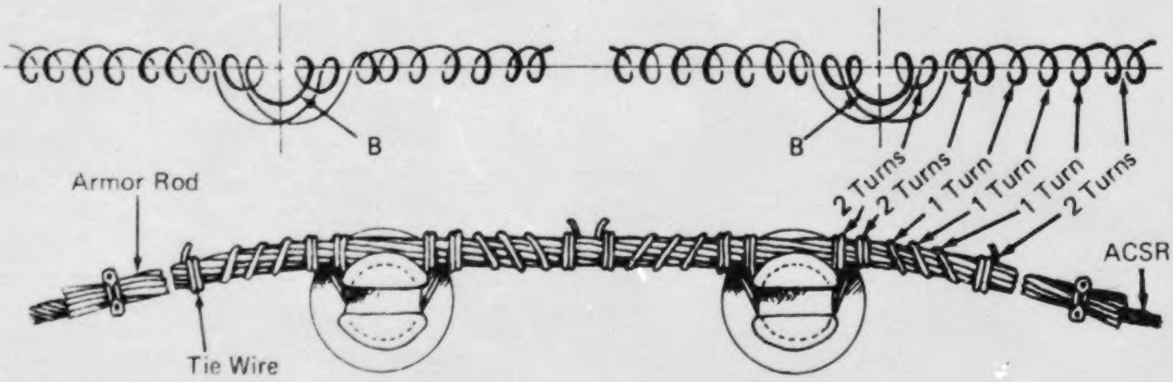
h. ______________________________


2 Turns
2 Turns
1 Turn
1 Turn
1 Turn
2 Turns
Tie Wire
ACSR
Armor Rod Clip

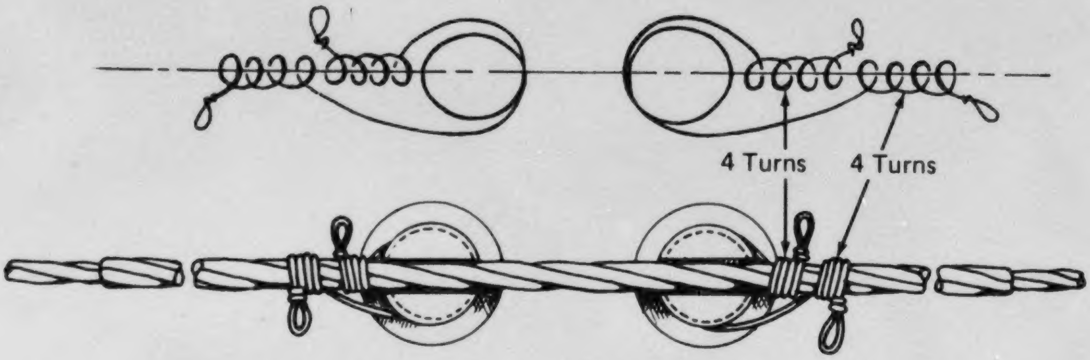
i. ______________________________


Starting Point
4 Turns
½ Turn

j. ______________________________


B
B
Armor Rod
2 Turns
2 Turns
1 Turn
1 Turn
1 Turn
2 Turns
ACSR
Tie Wire

k. ______________________________



I. ______________________________

8. Match the types of conductors on the right to the specific use.

_____a. Pole ground, tie wire, and jumper	1. ACSR
_____b. Primary and secondary	2. Copperweld copper
_____c. Secondary and service	3. Hard-drawn copper
	4. Soft-drawn copper
	5. Weatherproof

9. State the ground clearance for conductors carrying 750 volts or less over the following locations.

a. Over commercial parking lots and agricultural areas not subject to truck traffic

b. Over sidewalks or platforms from which the conductor may be reached

c. Over public streets, alleys, and driveways other than residential which are subject to truck traffic and roofs accessible to vehicular traffic

d. Over residential driveways and commercial areas not subject to truck traffic

10. Match the minimum conductor clearances on the right to the correct conductor voltages.

______a. Clearance over a roof for a conductor carrying 34,500 volts

______b. Clearance over a roof for a conductor carrying 240 volts

______c. Clearance from a side wall for a conductor carrying 14,400 volts

______d. Clearance from a side wall for a conductor carrying 7,200 volts

1. 8 feet
2. 5 feet
3. 17 feet
4. 15 feet

11. Match the approximate current-carrying capacities on the right to the correct ACSR conductor size.

______a. #4
1. 130
2. 140

______b. #2
1. 180
2. 160

______c. #1
1. 200
2. 210

______d. #1/0
1. 240
2. 230

______e. #2/0
1. 270
2. 280

______f. #3/0
1. 340
2. 300

______g. #4/0
1. 300
2. 340

______h. 266.8 mcm
1. 460
2. 340

______i. 300 mcm
1. 490
2. 530

______j. 336.4 mcm
1. 530
2. 490

______k. 397.5 mcm
1. 580
2. 590

______l. 477 mcm
1. 560
2. 670

_____m. 556.5 mcm

1. 730
2. 670

_____n. 605 mcm

1. 670
2. 760

_____o. 636 mcm

1. 870
2. 780

12. Match the current-carrying capacities on the right to the correct copperweld copper conductor size.

_____a. 8A

1. 90
2. 100

_____b. 6A

1. 140
2. 120

_____c. 4A

1. 180
2. 160

_____d. 2F

1. 250
2. 230

_____e. 1/0F

1. 330
2. 310

_____f. 3/0 F

1. 460
2. 410

13. Demonstrate the ability to:

a. Install a preformed line tie on ACSR conductor on a de-energized circuit.

b. Install a top groove conductor tie on a de-energized copper conductor.

c. Install a preformed armor rod on ACSR conductor.

d. Join ACSR conductor.

(NOTE: If these activities have not been accomplished prior to the test, ask the instructor when they should be completed.)

CONDUCTORS
UNIT II

ANSWERS TO TEST

1. Match the terms on the right to the correct definitions.

10 a. Aluminum conductor steel reinforced

12 b. Copperweld copper conductor

8 c. American wire gauge

6 d. To heat and let cool slowly to soften

5 e. Annealed wire

15 f. Steel wire with a welded coating of aluminum

13 g. Wire which has been tempered for strength

3 h. Area of a circle which is one-thousandth of an inch in diameter

2 i. One thousand circular mils

4 j. Steel conductor strung above transmission lines for a ground wire

11 k. Coating of neoprene or of braided cotton saturated with an asphalt compound

9 l. Unit of measure of electromotive force equal to one thousand volts

7 m. Steel core conductor with a welded coating of copper

1 n. Flat aluminum ribbon one-fourth inch wide

14 o. Tool used to join conductor with a sleeve

1. Armor tape
2. mcm
3. Circular mil
4. Static wire
5. Soft-drawn wire
6. Anneal
7. Copperweld
8. AWG
9. Kilovolt (kV)
10. ACSR
11. Weatherproofing
12. CWC
13. Hard-drawn wire
14. Crimping tool
15. Alumoweld wire

2. List three methods used to protect line conductor at supports.

   (NOTE: Any three of the following answers are acceptable.)

   a. Preformed armor rod

   b. Clip type armor rod

   c. Preformed conductor tie

   d. Armor tape

3. Arrange in order the steps to follow when joining an ACSR conductor. Place a "1" before the first step, a "2" before the second step, and so on.

   __5__ a. Slide conductor sleeve onto conductor

   __6__ b. Install and crimp core sleeve

   __2__ c. Select proper crimping tool

   __4__ d. Clean conductor with conductor brush

   __8__ e. Crimp conductor sleeve from center of sleeve outward

   __3__ f. Remove aluminum strands from steel core the distance recommended by splice manufacturer

   __7__ g. Slide center of conductor sleeve to center of core sleeve

   __1__ h. Select proper sleeve for wire size

4. Arrange in order the steps to follow when joining a CWC conductor. Place a "1" before the first step, a "2" before the second step, and so on.

   __4__ a. Install sleeve and crimp from center of sleeve outward

   __3__ b. Clean conductor with conductor brush

   __2__ c. Select proper crimping tool

   __1__ d. Select proper sleeve for wire size

5. List two classes of conductors.

   a. Solid

   b. Stranded

6. List three methods of reeling out conductor.

   a. Tie off end of conductor and move reel along line route

   b. Set up reel and pull conductor through structures or along the ground

c. Set up anchored reel with braking system and pull conductor under controlled tension through structures

7. Identify the following conductor ties.

a. ACSR conductor top groove double insulator double tie

b. Copper conductor side groove

c. ACSR conductor top groove double tie

d. Copper conductor top groove

e. ACSR conductor side groove preformed tie

f. ACSR conductor side groove double insulator hot line tie

g. ACSR conductor top groove preformed tie

h. Copper conductor top groove hot line tie

i. ACSR conductor side groove tie

j. Copper conductor side groove hot line tie

k. ACSR conductor side groove double insulator double tie

l. ACSR conductor top groove double insulator hot line tie

8. Match the types of conductors on the right to the specific use.

__4__ a. Pole ground, tie wire, and jumper
1,2,3 b. Primary and secondary
__5__ c. Secondary and service

1. ACSR
2. Copperweld copper
3. Hard-drawn copper
4. Soft-drawn copper
5. Weatherproof

9. State the ground clearance for conductors carrying 750 volts or less over the following locations.

a. Over commercial parking lots and agricultural areas not subject to truck traffic

16 feet

b. Over sidewalks or platforms from which the conductor may be reached

13 feet

c. Over public streets, alleys, and driveways other than residential which are subject to truck traffic and roofs accessible to vehicular traffic

16 feet

d. Over residential driveways and commercial areas not subject to truck traffic

13 feet

10. Match the minimum conductor clearances on the right to the correct conductor voltages.

3	a.	Clearance over a roof for a conductor carrying 34,500 volts	1.	8 feet
4	b.	Clearance over a roof for a conductor carrying 240 volts	2.	5 feet
1	c.	Clearance from a side wall for a conductor carrying 14,400 volts	3.	17 feet
2	d.	Clearance from a side wall for a conductor carrying 7,200 volts	4.	15 feet

11. Match the approximate current-carrying capacities on the right to the correct ACSR conductor size.

2	a.	#4	1. 2.	130 140
1	b.	#2	1. 2.	180 160
1	c.	#1	1. 2.	200 210
2	d.	#1/0	1. 2.	240 230
1	e.	#2/0	1. 2.	270 280
2	f.	#3/0	1. 2.	340 300
2	g.	#4/0	1. 2.	300 340
1	h.	266.8 mcm	1. 2.	460 340
1	i.	300 mcm	1. 2.	490 530

1 j. 336.4 mcm
1. 530
2. 490

2 k. 397.5 mcm
1. 580
2. 590

2 l. 477 mcm
1. 560
2. 670

1 m. 556.5 mcm
1. 730
2. 670

2 n. 605 mcm
1. 670
2. 760

2 o. 636 mcm
1. 870
2. 780

12. Match the current-carrying capacities on the right to the correct copperweld copper conductor size.

2 a. 8A
1. 90
2. 100

1 b. 6A
1. 140
2. 120

1 c. 4A
1. 180
2. 160

2 d. 2F
1. 250
2. 230

2 e. 1/0 F
1. 330
2. 310

2 f. 3/0 F
1. 460
2. 410

13. Demonstrate the ability to:

a. Install a preformed line tie on ACSR conductor on a de-energized circuit.

b. Install a top groove conductor tie on a de-energized copper conductor.

c. Install a preformed armor rod on ACSR conductor.

d. Join ACSR conductor.

(NOTE: Performance skills will be evaluated to the satisfaction of the instructor.)

GROUNDING AND CONNECTING
UNIT III

UNIT OBJECTIVE

After completion of this unit, the student should be able to state the procedure for installing temporary protective grounds and arrange in order the steps to follow when disconnecting and grounding a sectionalizer or recloser station and a multi-phase vertical corner. This knowledge will be evidenced by scoring 85 percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms commonly associated with grounds and connectors to the correct definitions.
2. State the purposes of grounding.
3. List methods of grounding.
4. Select from a list those elements necessary for good grounding.
5. Select from a list equipment which must be grounded.
6. State the correct procedure for installing temporary protective grounds.
7. Arrange in order the steps to follow when disconnecting and grounding at sectionalizer or recloser station.
8. Arrange in order the steps to follow when disconnecting and grounding at multi-phase vertical corner.
9. State procedure for installing temporary protective grounds at air-break switch on a transmission line.
10. List elements of a good connection.

GROUNDING AND CONNECTING
UNIT III

SUGGESTED ACTIVITIES

I. Suggested activities for instructor:

   A. Provide student with objective sheet.

   B. Provide student with information sheet.

   C. Discuss unit and specific objectives.

   D. Discuss information sheet.

   E. Give test.

II. Unit references:

   A. Rural Electrification Administration. *Guide for Electric Service on Three Phase Motor Installations.* REA Bulletin 161-19. Washington, D.C.: U.S. Department of Agriculture, April 1972.

   B. Kurtz, Edwin B., and Shoemaker, Thomas M. *The Lineman's and Cableman's Handbook.* 5th ed. New York: McGraw-Hill Book Co., 1976.

GROUNDING AND CONNECTING
UNIT III

INFORMATION SHEET

I. Terms and definitions

  A. Mobile equipment grounding--Installing a driven ground or connecting equipment to an existing ground (Transparency 1)

  B. Line grounding--Connecting the line neutral to the pole ground (Transparency 2)

  C. Equipment grounding--Connecting the tank, frame, or housing of equipment to a ground

  D. Protective ground--Ground installed to protect persons which may come in contact with equipment

  E. "Swinging" ground--Ground on a primary circuit which is irregular

  F. "Light" ground--Ground which has poor contact or high resistance to earth

  G. "Solid" ground--Ground which has little resistance between the circuit and earth

  H. Inhibitor--Substance used on conductors to prevent oxidation or corrosion and to help make a better connection

  I. Ground resistance--Resistance caused by poor connection or poor soil condition

  J. Temporary ground--Ground installed by a line technician for personal protection (Transparency 3)

  K. Hold card--Tag placed at disconnect point to prevent someone else from re-energizing line (Transparency

  (NOTE: The person who installs the hold card should be the one to remove it.)

  L. Running ground--Ground used on conductor being pulled (Transparency 3)

II. Purposes of grounding

  A. Prevent injury to persons

  B. Protect lines and equipment from lightning

  C. Drain off unwanted voltage and current

  Examples: Induced voltage, lightning

INFORMATION SHEET

III. Methods of grounding

  A. Driven rod

  B. Screw-in rod

  C. Coil or plate fastened to bottom of pole

  D. Buried metal mat

IV. Elements necessary for good grounding

  A. Contact with moist soil

  B. Metal construction that resists corrosion

  C. Capacity for maximum current surges

  D. Low resistance to earth

  (NOTE: Grounding cables must be #2 AWG copper or equivalent. Larger conductors will require large grounding cable.)

V. Equipment which must be grounded

  A. Mobile equipment working near energized lines

  B. Lightning arrester

  C. Voltage regulator tank

  D. Transformer tank

  E. Transformer platform

  F. Guy wire

  G. Capacitor rack

  H. Current and potential transformers

  I. Hand-operated switch gear

  J. Metal pole

  K. Metal conduit

  L. Metering equipment

  M. Switch box

  N. Cable sheath

  O. Motor casing

INFORMATION SHEET

VI. Procedure for installing temporary protective grounds (Transparency 4)

(NOTE: Receive clearance from dispatcher before disconnecting any line.)

A. Disconnect line jumper and fasten it back on itself

B. Test line for potential

C. Attach one end of grounding cable to neutral

D. Attach other end of grounding cable to phase wire

E. Attach hold card

F. Install grounds within sight on both sides of work area on all conductors

(NOTE: Always use a hot stick to disconnect and ground a circuit.)

VII. Steps to follow when disconnecting and grounding at sectionalizer or recloser station (Transparency 4)

A. Move operating handle to Off position with hot stick

B. Remove source side jumper and fasten it back on itself

C. Remove load side jumper and fasten it back on itself or on the neutral

D. Attach ground cable to neutral on load side and then to phase wire on load side

E. Attach hold card

(NOTE: Notify the dispatcher before any line is disconnected.)

VIII. Steps to follow when disconnecting and grounding at multi-phase vertical corner (Transparency 5)

A. Disconnect all phases, starting with the bottom phase and going upward, and fasten each jumper back on its own line

B. Attach ground cable to neutral wire and then to bottom phase wire

C. Attach ground cable to bottom phase and connect to center phase

D. Attach ground cable to center phase and connect to top phase

E. Attach hold card

(NOTE: A 12-foot hot stick is required to disconnect and ground a multi-phase vertical corner.)

(CAUTION: The source side of the line will still be energized.)

INFORMATION SHEET

IX. Procedure for installing temporary protective grounds at air-break switch on transmission line (Transparency 6)

(NOTE: Clearance from the dispatcher must be obtained before switch is opened.)

A. Open switch

(NOTE: Use a quick, sure motion when opening switch. Do not hesitate after switch has started to open.)

B. Check switch blades visually to see that they are open

C. Lock switch open

D. Connect ground cable to driven or screw-in ground rod or to line neutral if accessible

E. Attach ground cable to center phase wire on load side of switch

F. Connect short ground cables to center grounded phase and to both outside phase wires

(NOTE: Always connect grounding cables to neutral or ground rod first.)

X. Elements of a good connection

A. Connector sized to conductor being connected

B. Clean conductor

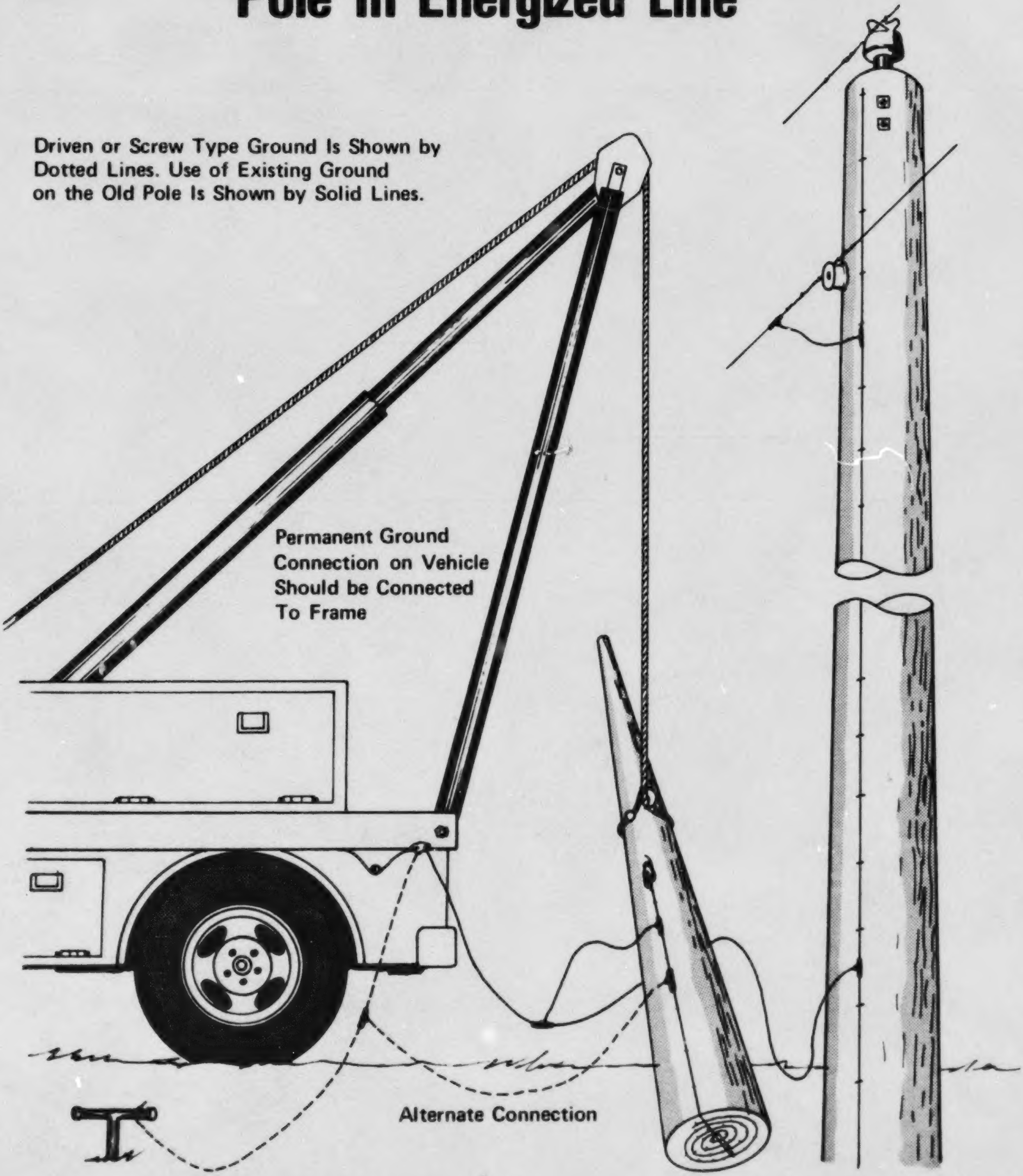
C. Proper connector for type of conductor

Examples: Copper to copper, aluminum to aluminum, copper to aluminum

(NOTE: Connectors will indicate what type of conductor they are used for by stating *cu-al* for copper to aluminum, *cu-cu* for copper to copper, and *al-al* for aluminum to aluminum.)

D. Inhibitor applied to conductor

Method of Grounding Truck While Setting or Removing Pole In Energized Line

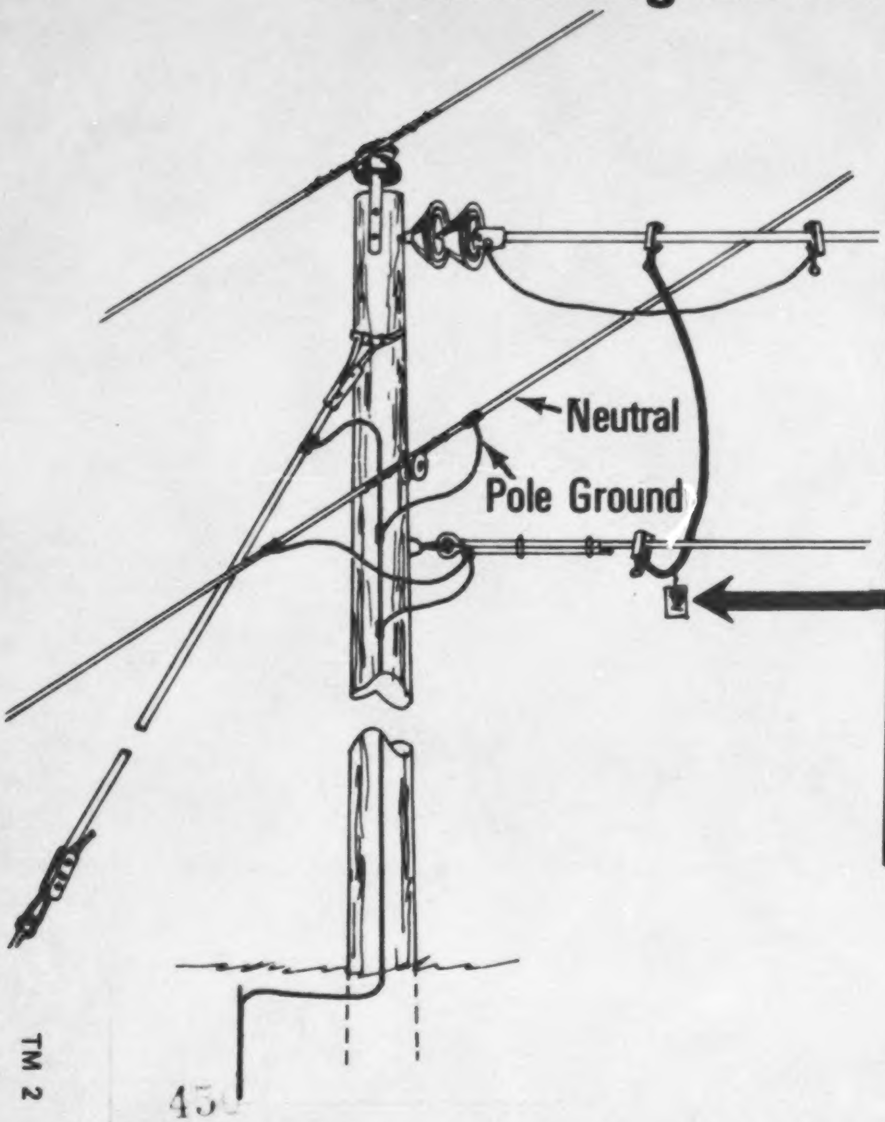


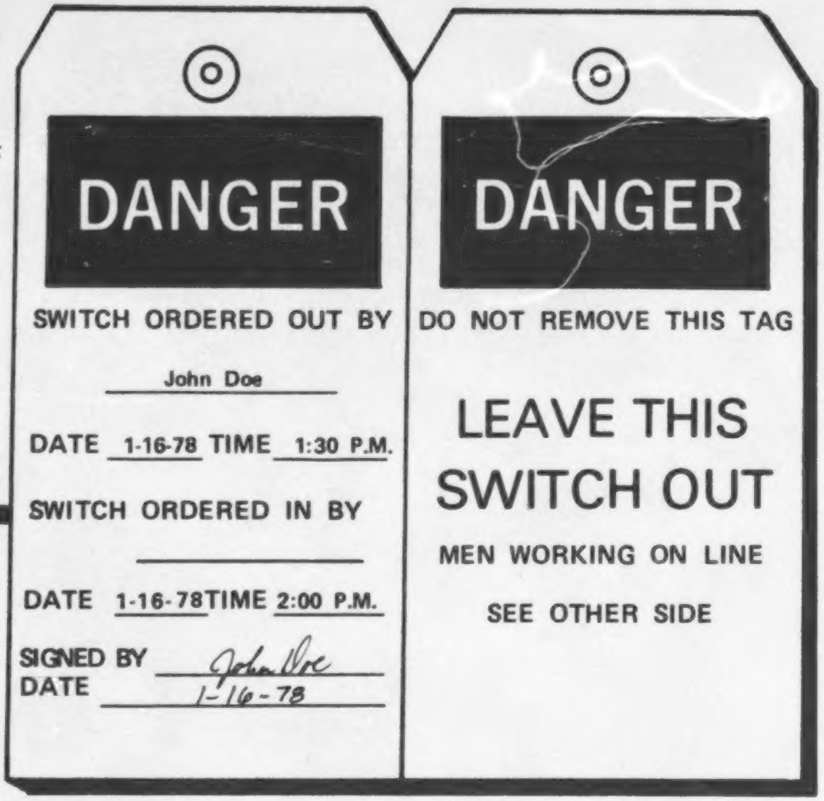
Driven or Screw Type Ground Is Shown by Dotted Lines. Use of Existing Ground on the Old Pole Is Shown by Solid Lines.

Permanent Ground Connection on Vehicle Should be Connected To Frame

Alternate Connection

Disconnecting and Grounding a Tap Line





DANGER

SWITCH ORDERED OUT BY

John Doe

DATE 1-16-78 TIME 1:30 P.M.

SWITCH ORDERED IN BY

DATE 1-16-78 TIME 2:00 P.M.

SIGNED BY John Doe
DATE 1-16-78

DANGER

DO NOT REMOVE THIS TAG

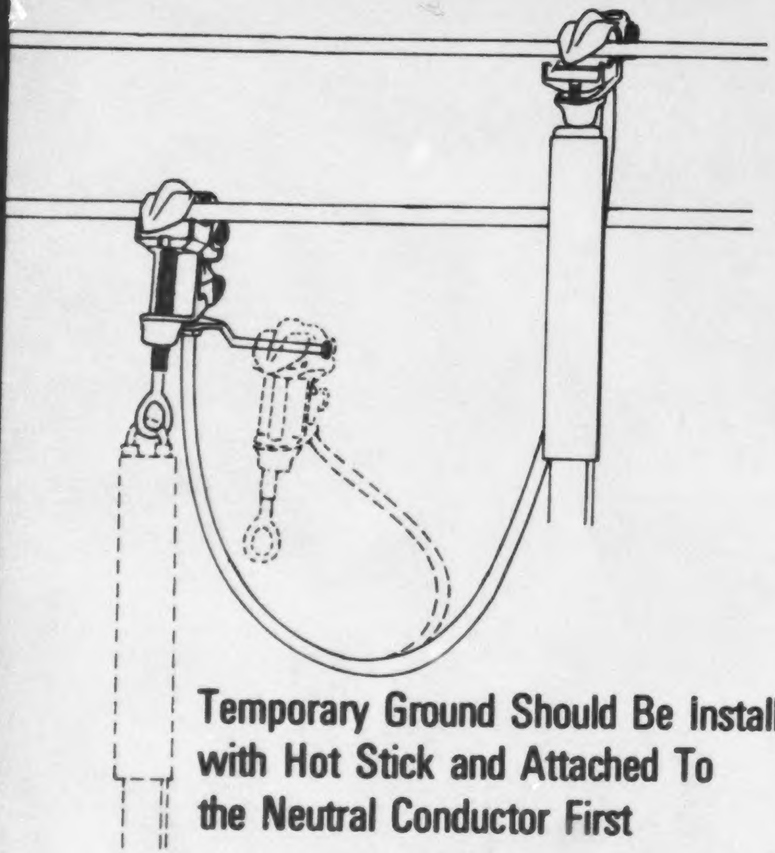
LEAVE THIS SWITCH OUT

MEN WORKING ON LINE

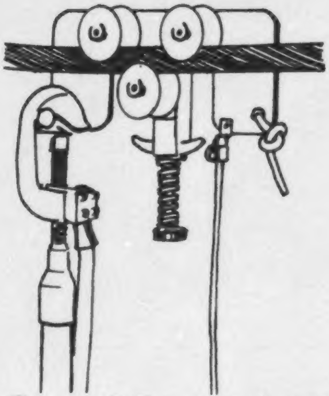
SEE OTHER SIDE

Hold Card

Temporary Grounds

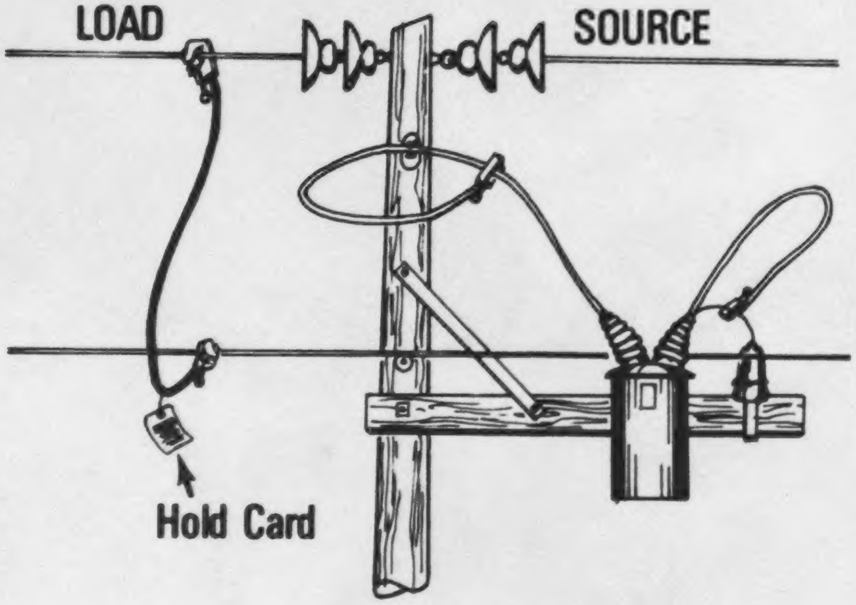


Temporary Ground Should Be Installed with Hot Stick and Attached To the Neutral Conductor First

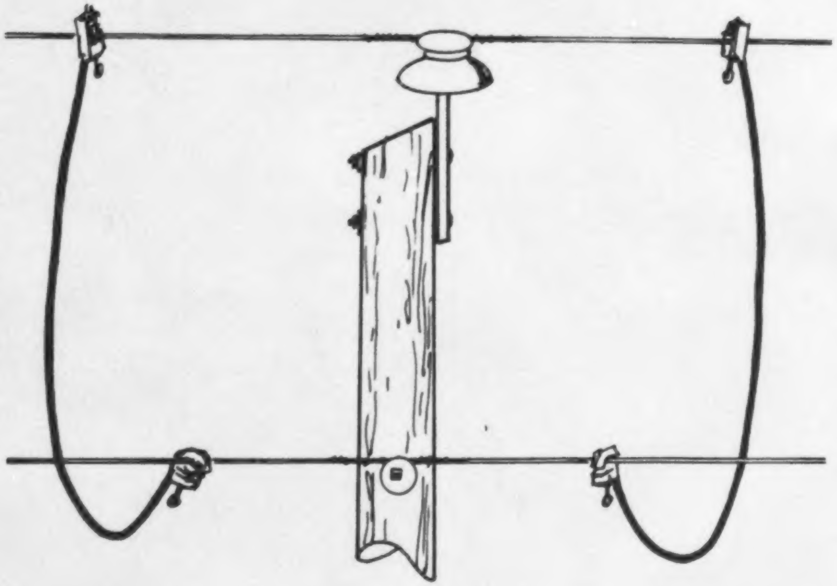


Running Ground Device Used On Moving Conductor While Stringing and Sagging Is Being Done

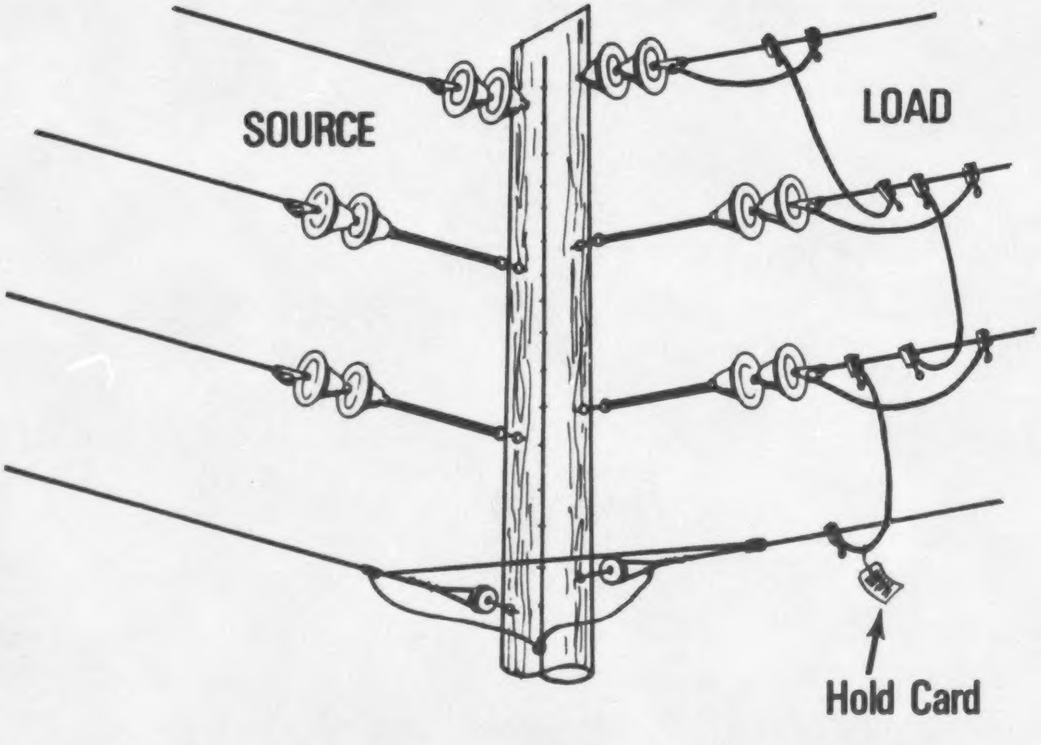
Protective Grounds At Work Area



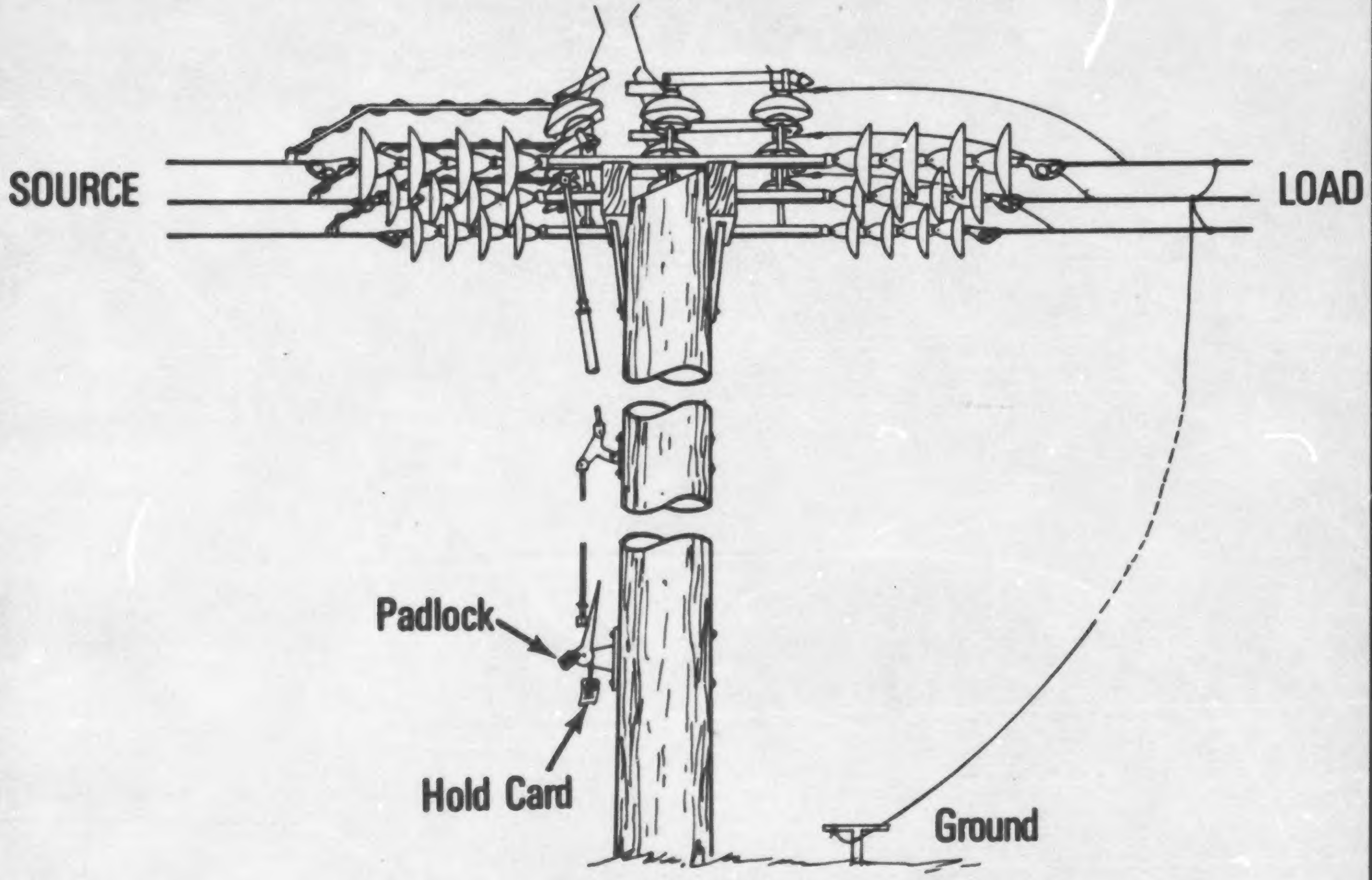
Disconnecting and Grounding
At Recloser or Sectionalizer



Disconnecting and Grounding Multi-Phase Vertical Corners



Disconnecting and Grounding an Air-Break Switch



GROUNDING AND CONNECTING
UNIT III

TEST

NAME ________________________________ SCORE ____________________

1. Match the terms on the right to the correct definitions.

_____a. Installing a driven ground or connecting equipment to an existing ground

_____b. Connecting the line neutral to the pole ground

_____c. Connecting the tank, frame, or housing of equipment to a ground

_____d. Ground installed to protect persons which may come in contact with equipment

_____e. Ground on a primary circuit which is irregular

_____f. Ground which has poor contact or high resistance to earth

_____g. Ground which has little resistance between the circuit and earth

_____h. Substance used on conductors to prevent oxidation or corrosion and to help make a better connection

_____i. Resistance caused by poor connection or poor soil condition

_____j. Ground installed by a line technician for personal protection

_____k. Tag placed at disconnect point to prevent someone else from re-energizing line

_____l. Ground used on conductor being pulled

1. Ground resistance
2. Hold card
3. Temporary ground
4. Line grounding
5. "Swinging" ground
6. "Solid" ground
7. Inhibitor
8. Protective ground
9. "Light" ground
10. Equipment grounding
11. Running ground
12. Mobile equipment grounding

2. State three purposes of grounding.

a. ____

b. ____

c. ____

3. List three methods of grounding.

a. ______________________________

b. ______________________________

c. ______________________________

4. Select from the following list those elements necessary for good grounding.

______a. Contact with moist soil

______b. High impedance to ground

______c. Metal construction that resists corrosion

______d. Low resistance to earth

______e. Small conductor with high resistance

______f. Capacity for maximum current surges

5. Select from the following list equipment which must be grounded.

______a. Metal conduit

______b. Metering equipment

______c. Cable sheath

______d. Hand-operated switch gear

______e. Plastic conduit

______f. Current and potential transformers

______g. Metal pole

______h. Wooden crossarm

______i. Guy wire

______j. Transformer tank

______k. Motor casing

______l. Capacitor rack

______m. Transformer platform

______n. Voltage regulator tank

______o. Lightning arrester

______p. Switch box

______q. Mobile equipment working near energized lines

6. State the correct procedure for installing temporary protective grounds.

a. ______________________________

____

b. ______________________________

____

c. ______________________________

____

d. ______________________________

____

e. ______________________________

____

f. ______________________________

____

7. Arrange in correct order the steps to follow when disconnecting and grounding at sectionalizer or recloser station. Place a "1" in front of the first step, a "2" in front of the second step, and so on.

______a. Attach hold card

______b. Remove source side jumper and fasten it back on itself

______c. Move operating handle to Off position with hot stick

______d. Attach ground cable to neutral on load side and then to phase wire on load side

______e. Remove load side jumper and fasten it back on itself or on the neutral

8. Arrange in order the steps to follow when disconnecting and grounding at multi-phase vertical corner. Place a "1" in front of the first step, a "2" in front of the second step, and so on.

______a. Attach ground cable to center phase and connect to top phase

______b. Attach ground cable to bottom phase and connect to center phase

______c. Attach hold card

______d. Disconnect all phases, starting with the bottom phase and going upward, and fasten each jumper back on its own line

______e. Attach ground cable to neutral wire and then to bottom phase wire

9. State the procedure for installing temporary protective grounds at air-break switch on a transmission line.

a. ______________________________
____

b. ______________________________
____

c. ______________________________
____

d. ______________________________
____

e. ______________________________
____

f. ______________________________
____

10. List four elements of a good connection.

a. ______________________________

b. ______________________________

c. ______________________________

d. ______________________________

GROUNDING AND CONNECTING
UNIT III

ANSWERS TO TEST

1. Match the terms on the right to the correct definitions.

__12__ a. Installing a driven ground or connecting equipment to an existing ground

__4__ b. Connecting the line neutral to the pole ground

__10__ c. Connecting the tank, frame, or housing of equipment to a ground

__8__ d. Ground installed to protect persons which may come in contact with equipment

__5__ e. Ground on a primary circuit which is irregular

__9__ f. Ground which has poor contact or high resistance to earth

__6__ g. Ground which has little resistance between the circuit and earth

__7__ h. Substance used on conductors to prevent oxidation or corrosion and to help make a better connection

__1__ i. Resistance caused by poor connection or poor soil condition

__3__ j. Ground installed by a line technician for personal protection

__2__ k. Tag placed at disconnect point to prevent someone else from re-energizing line

__11__ l. Ground used on conductor being pulled

1. Ground resistance
2. Hold card
3. Temporary ground
4. Line grounding
5. "Swinging" ground
6. "Solid" ground
7. Inhibitor
8. Protective ground
9. "Light" ground
10. Equipment grounding
11. Running ground
12. Mobile equipment grounding

2. State three purposes of grounding.

a. Prevent injury to persons

b. Protect lines and equipment from lightning

c. Drain off unwanted voltage and current

3. List three methods of grounding.

   (NOTE: Any three of the following methods are acceptable.)

   a. Driven rod

   b. Screw-in rod

   c. Coil or plate fastened to bottom of pole

   d. Buried metal mat

4. Select from the following list those elements necessary for good grounding.

   X a. Contact with moist soil

   ____ b. High impedance to ground

   X c. Metal construction that resists corrosion

   X d. Low resistance to earth

   ____ e. Small conductor with high resistance

   X f. Capacity for maximum current surges

5. Select from the following list equipment which must be grounded.

   X a. Metal conduit

   X b. Metering equipment

   X c. Cable sheath

   X d. Hand-operated switch gear

   ____ e. Plastic conduit

   X f. Current and potential transformers

   X g. Metal pole

   ____ h. Wooden crossarm

   X i. Guy wire

   X j. Transformer tank

   X k. Motor casing

   X l. Capacitor rack

   X m. Transformer platform

   X n. Voltage regulator tank

__X__ o. Lightning arrester

__X__ p. Switch box

__X__ q. Mobile equipment working near energized lines

6. State the correct procedure for installing temporary protective grounds.

   a. Disconnect line jumper and fasten it back on itself

   b. Test line for potential

   c. Attach one end of grounding cable to neutral

   d. Attach other end of grounding cable to phase wire

   e. Attach hold card

   f. Install grounds within sight on both sides of work area on all conductors

7. Arrange in correct order the steps to follow when disconnecting and grounding at sectionalizer or recloser station. Place a "1" in front of the first step, a "2" in front of the second step, and so on.

   __5__ a. Attach hold card

   __2__ b. Remove source side jumper and fasten it back on itself

   __1__ c. Move operating handle to Off position with hot stick

   __4__ d. Attach ground cable to neutral on load side and then to phase wire on load side

   __3__ e. Remove load side jumper and fasten it back on itself or on the neutral

8. Arrange in order the steps to follow when disconnecting and grounding at multi-phase vertical corner. Place a "1" in front of the first step, a "2" in front of the second step, and so on.

   __4__ a. Attach ground cable to center phase and connect to top phase

   __3__ b. Attach ground cable to bottom phase and connect to center phase

   __5__ c. Attach hold card

   __1__ d. Disconnect all phases, starting with the bottom phase and going upward, and fasten each jumper back on its own line

   __2__ e. Attach ground cable to neutral wire and then to bottom phase wire

9. State the procedure for installing temporary protective grounds at air-break switch on a transmission line.
    a. Open switch
    b. Check switch blades visually to see that they are open
    c. Lock switch open
    d. Connect ground cable to driven or screw-in ground rod or to line neutral if accessible
    e. Attach ground cable to center phase wire on load side of switch
    f. Connect short ground cables to center grounded phase and to both outside phase wires

10. List four elements of a good connection.
    a. Connector sized to conductor being connected
    b. Clean conductor
    c. Proper connector for type of conductor
    d. Inhibitor applied to conductor

GENERATORS AND BATTERIES
UNIT IV

UNIT OBJECTIVE

After completion of this unit, the student should be able to identify various circuits and connect batteries in series and parallel. The student should be able to use precautions when connecting batteries. This knowledge will be evidenced by scoring 85 percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms associated with generators and batteries to the correct definitions.
2. List kinds of generating plants.
3. Match specific kinds of generating plants to the voltages produced by each.
4. Match various kinds of generators to the specific uses.
5. Calculate the frequency of various generators.
6. List precautions to observe with the use of generators.
7. List kinds of voltage-producing cells.
8. Identify various circuits of connected batteries.
9. Select from a list precautions to observe when connecting batteries.
10. Arrange in order steps to connect batteries.
11. Connect batteries in series and parallel.

GENERATORS AND BATTERIES
UNIT IV

SUGGESTED ACTIVITIES

I. Suggested activities for instructor:

   A. Provide student with objective sheet.

   B. Provide student with information and assignment sheets.

   C. Make transparencies.

   D. Discuss unit and specific objectives.

   E. Discuss information and assignment sheets.

   F. Give test.

II. Unit references:

   A. Bureau of Navy Personnel. *Basic Electricity*. Navpers 10086-B. Washington, D.C.: U.S. Government Printing Office, 1969.

   B. Kurtz, Edwin B., and Shoemaker, Thomas M. *The Lineman's and Cableman's Handbook*. 5th ed. New York: McGraw-Hill Book Co., 1976.

GENERATORS AND BATTERIES
UNIT IV

INFORMATION SHEET

I. Terms and definitions

A. Hydroelectric power--Electrical power generated by using flowing water to turn generators

B. Steam plant--Generation plant powered by steam created by oil, coal, or natural gas heat

C. Atomic plant--Generation plant powered by steam created by atomic energy

D. Diesel plant--Generation plant powered by a diesel-fueled engine

E. Alternator--Alternating current generator which produces current by rotating a magnetic field close to stator coil (Transparency 1)

F. Polyphase alternator--Alternator which produces four or more voltage peaks at different intervals in time in one cycle (Transparency 2)

(NOTE: The standard polyphase alternator in use today produces six peaks, which is three-phase power.)

G. Electrolyte--Sulfuric acid used in lead-acid storage batteries

H. Specific gravity--Weight of electrolyte as compared to water

I. Hydrometer--Instrument used to measure the specific gravity of electrolyte in a lead-acid storage battery (Transparency 3)

J. Primary cell--Electricity-producing cell which is of no value when the electrical activity is exhausted

K. Secondary cell--Electricity-producing cell which can be restored to activity by passing a current through it in a reverse direction

L. Rectifier--Device which converts alternating current to direct current

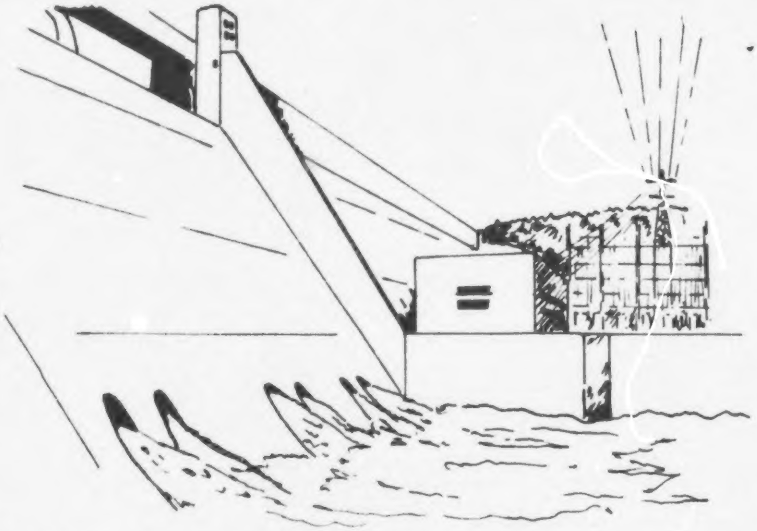
M. Generator--Machine that converts mechanical energy to electrical energy

N. Battery--Two or more primary or secondary cells connected electrically

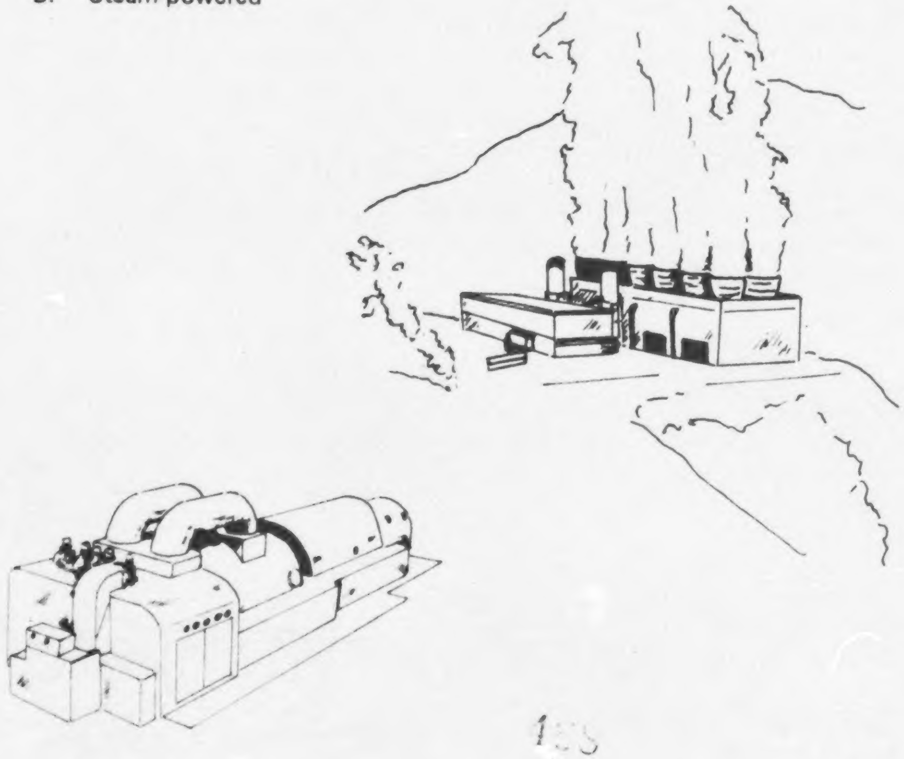
INFORMATION SHEET

II. Kinds of generating plants

A. Hydroelectric

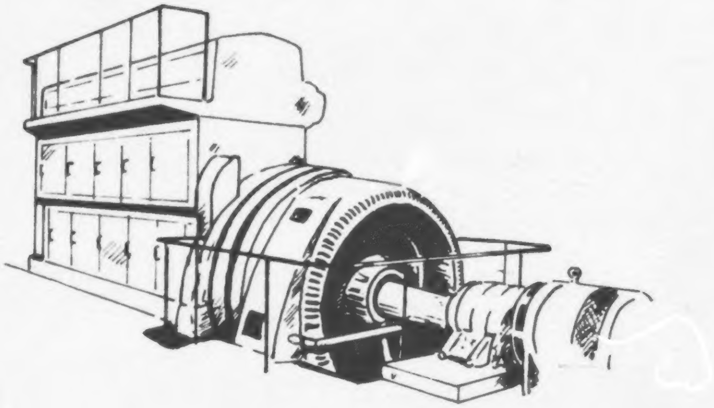


B. Steam-powered



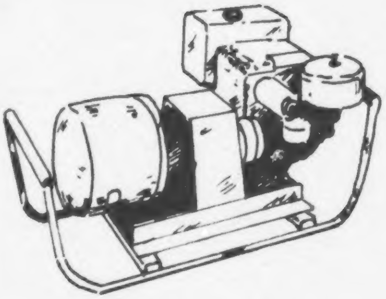
INFORMATION SHEET

C. Diesel-powered



D. Gasoline-powered

1. Portable



2. Mobile or stationary

III. Voltages produced by generators

A. Steam and hydroelectric plants--13,800 to 18,000 volts

B. Diesel-powered plant--1600 to 2400 volts

C. Gasoline-powered portable generator--120 to 480 volts

IV. Uses of generators

A. Hydroelectric or steam plant--Supplies power to large areas

B. Diesel-powered plant--Supplies power to small towns or supplements larger plants during peak loads

INFORMATION SHEET

C. Gasoline-powered mobile or stationary generator--Supplies emergency or standby power for farms and businesses

D. Gasoline-powered portable generator--Supplies temporary power for construction sites for power tools and lighting

V. Electrical frequency (Hertz)--Determined by number of poles times the revolutions per minute divided by 120

Formula:

$$\text{Frequency in cycles} = \frac{\text{No. of poles} \times \text{rpm}}{120}$$

(NOTE: A cycle or Hertz is completed when the rotor passes two poles of opposite polarity.)

VI. Precautions to observe with the use of portable generators

A. Ground the generator housing

B. Use a three-wire power cord with ground wire (120 V supply)

C. Check all standby generators for live connections

(NOTE: A standby or emergency power generator must be equipped with a switch that will not allow the generator to energize the line which it is replacing because of an outage.)

D. Do not connect a generator to an energized line

VII. Types and kinds of voltage-producing cells

A. Primary cells

1. Zinc-carbon
2. Mercury-zinc

B. Secondary cells

1. Lead-acid
2. Nickel-cadium

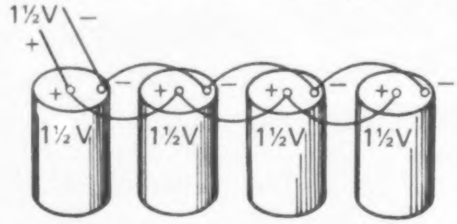
(NOTE: Primary cells are of no value when exhausted; secondary cells may be recharged.)

INFORMATION SHEET

VIII. Battery connections

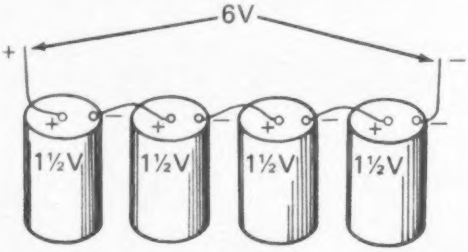
A. Parallel connected--Positive (+) to positive and negative (-) to negative

(NOTE: The voltage of parallel-connected batteries will be the same as if only one battery were used. The current output will be increased by the number of batteries used times the output of one battery.)

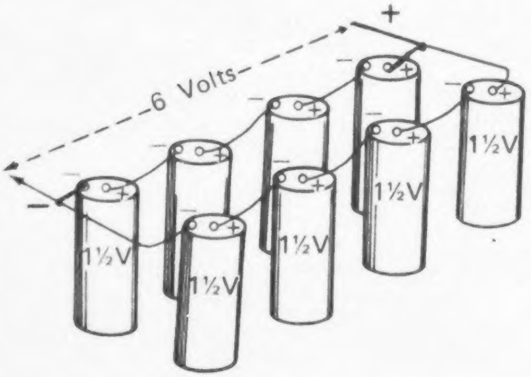


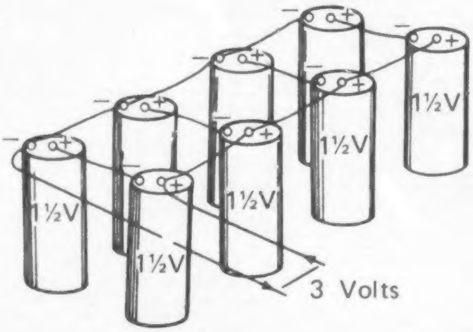
B. Series connected--Negative (-) to positive (+)

(NOTE: The voltage of series-connected batteries is the voltage of one battery times the number of batteries in the circuit.)



C. Series-parallel connected--Negative (-) to positive (+) in the series; positive to positive and negative to negative in parallel





INFORMATION SHEET

IX. Precautions to observe when connecting batteries

  A. Wear eye protection

  B. Do not short-circuit a battery

  (NOTE: Jumper between positive and negative terminals.)

  C. Do not series-connect batteries unless the voltage desired is more than the voltage of one battery

  D. Do not allow sparks or open flame near a lead-acid battery

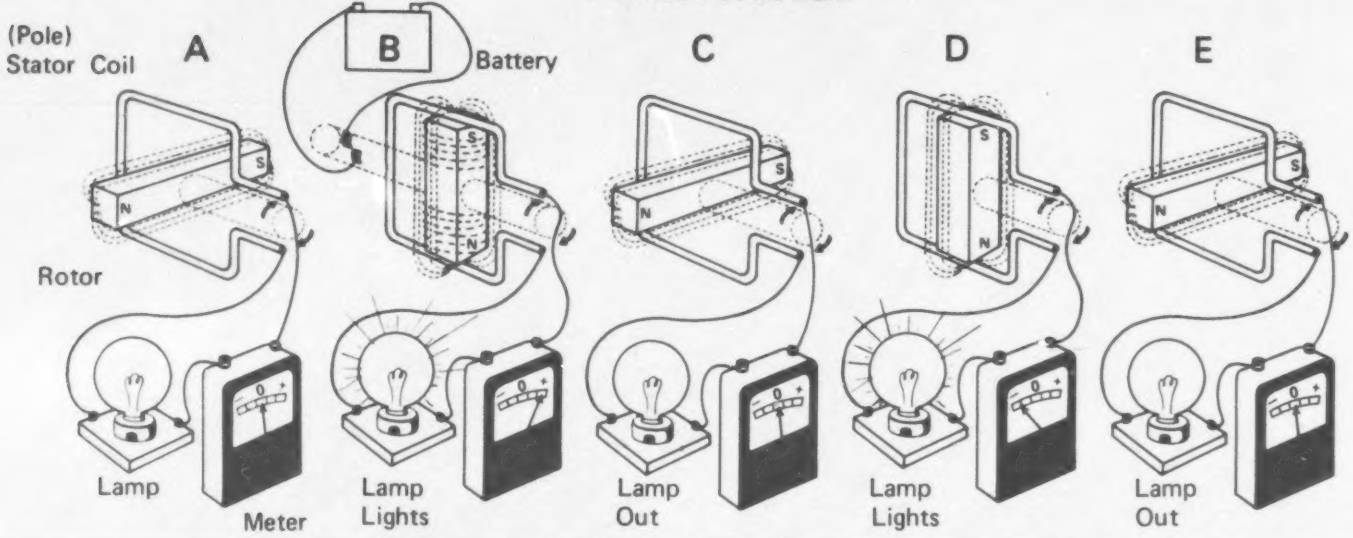
X. Steps to follow to connect lead-acid batteries when starting equipment (Transparency 4)

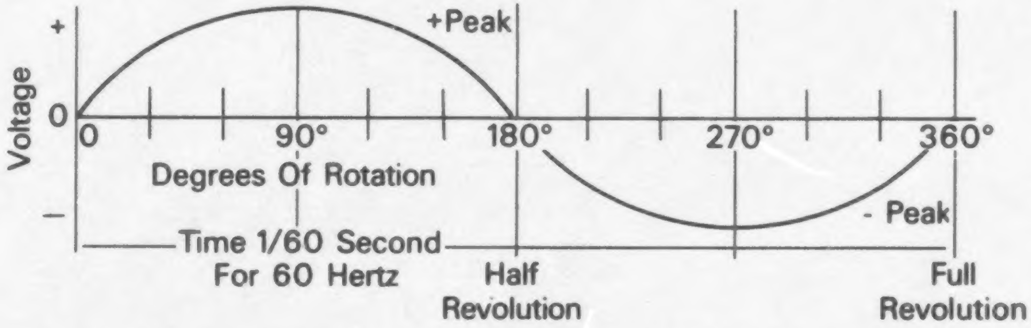
  A. Connect first jumper to positive terminal of each battery

  B. Connect second jumper to negative terminal of charged battery

  C. Connect other end of second jumper to the frame of equipment being started

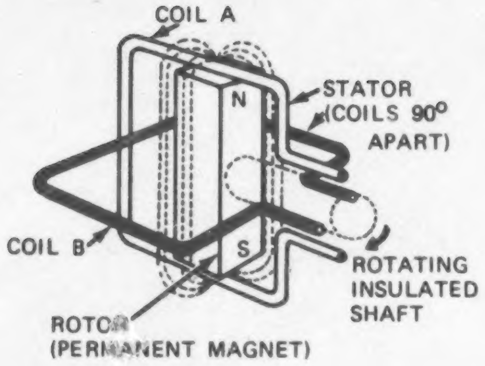
Alternator



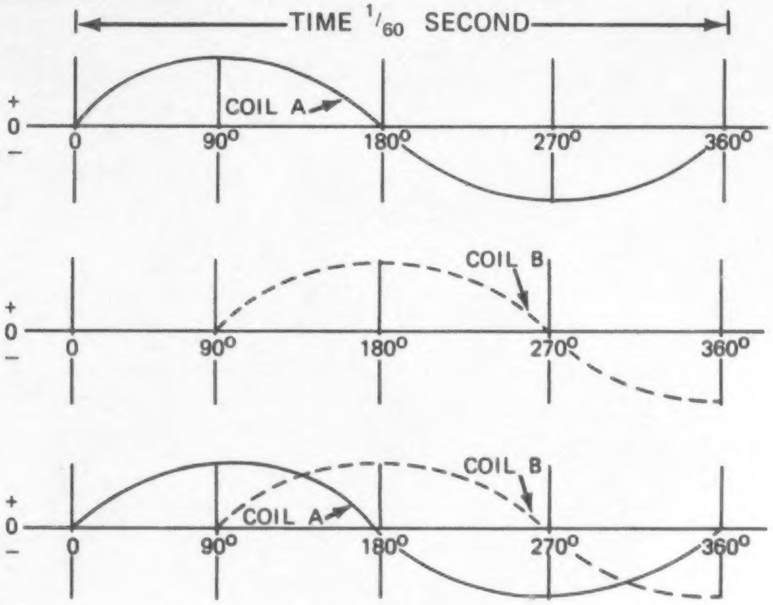


In Figure "B," A Field Coil Has Been Added. The Battery Supplies "Exciting" Current Which Increases The Magnetic Field Around The Rotor. The Stronger Field Around The Rotor Enables The Alternator To Produce A Greater Amount Of Alternating Current.

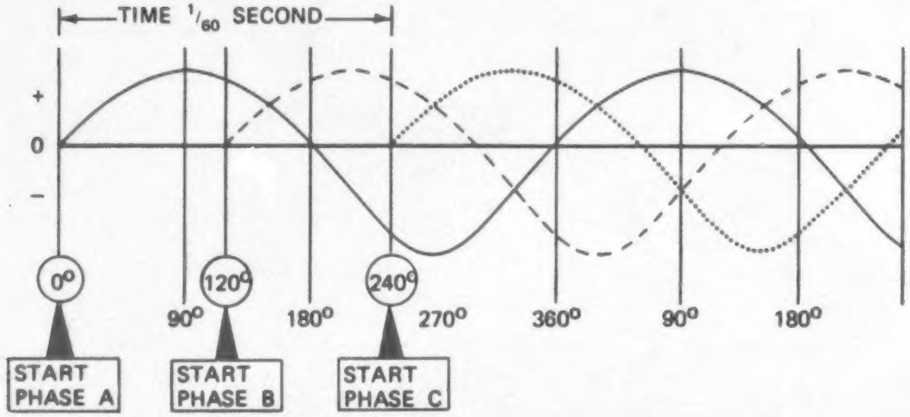
Polyphase Alternator



Polyphase Alternator
(2 Phase)

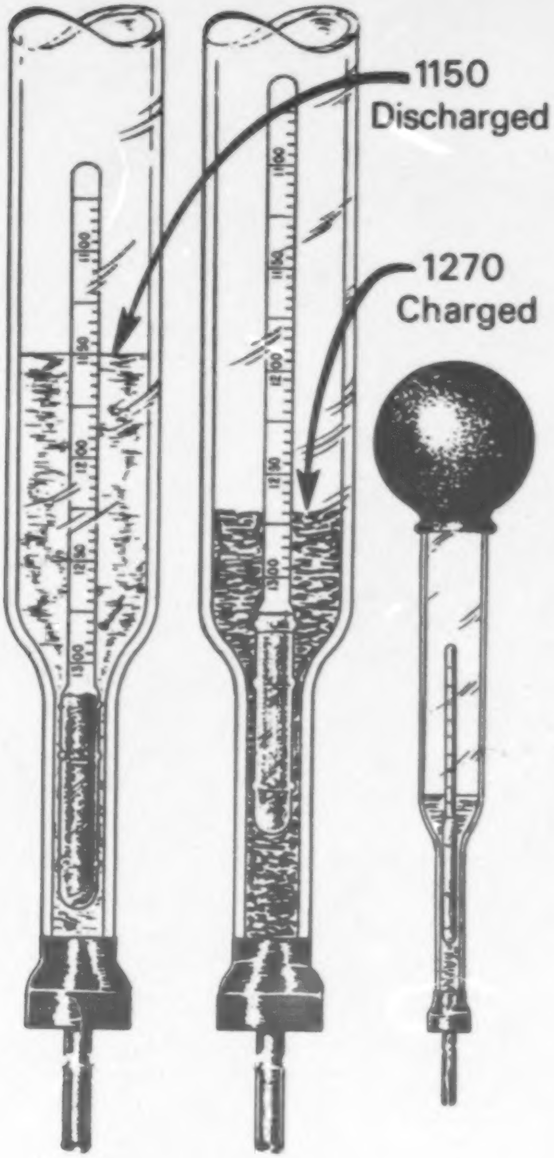


Sine Curves Of A Two-phase Alternator



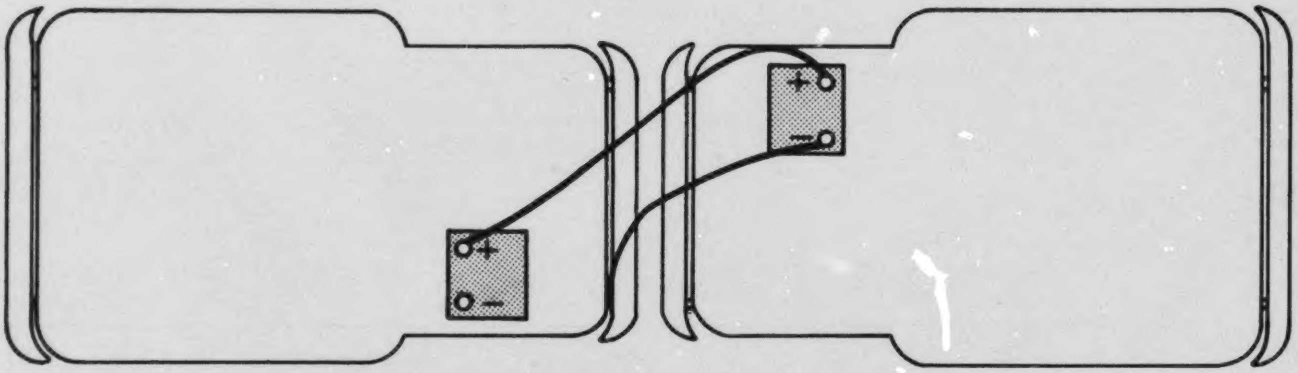
If A Third Stator Is Added To The Alternator A Three Phase Alternator Would Be Created With The Stators 120 Degrees Apart.

Hydrometer



SPECIFIC GRAVITY	STATE OF CHARGE
1.260 to 1.280	Fully charged
1.225 to 1.250	Three-fourths charged
1.195 to 1.220	One-half charged
1.160 to 1.180	One-fourth charged
1.130 to 1.155	Barely usable
1.100 to 1.125	Completely discharged

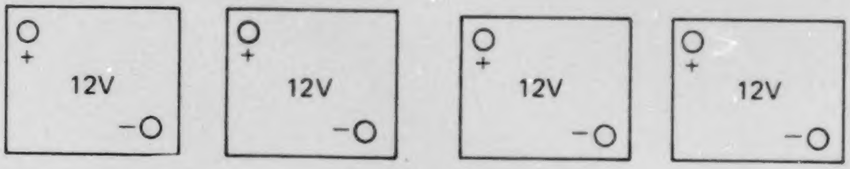
Jumping Vehicle Batteries



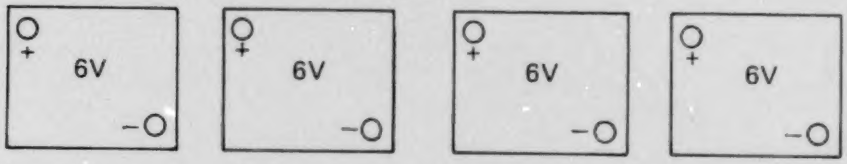
GENERATORS AND BATTERIES
UNIT IV

ASSIGNMENT SHEET #1--CONNECT BATTERIES IN SERIES AND PARALLEL

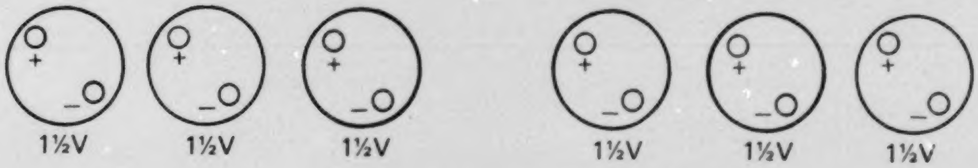
1. Draw in the lines between the batteries to connect them in series and state the voltage that will be produced.



2. Draw in the lines between the batteries to connect them in parallel and state the voltage that will be produced.



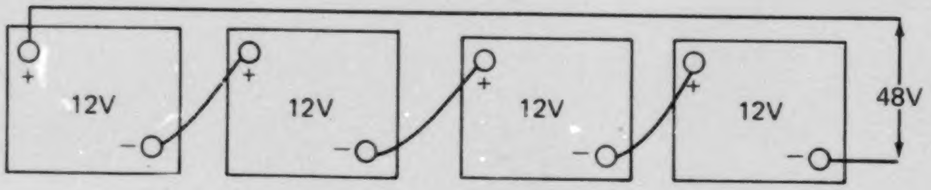
3. Draw in the lines between the three batteries on the right to connect them in series. Draw in the lines on the three batteries on the left to connect them in series. Draw lines between the group on the right and the group on the left to connect the two groups in parallel. State the voltage produced from the two groups.



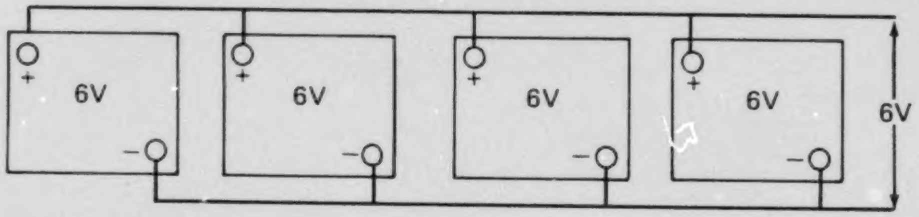
GENERATORS AND BATTERIES
UNIT IV

ANSWERS TO ASSIGNMENT SHEET #1

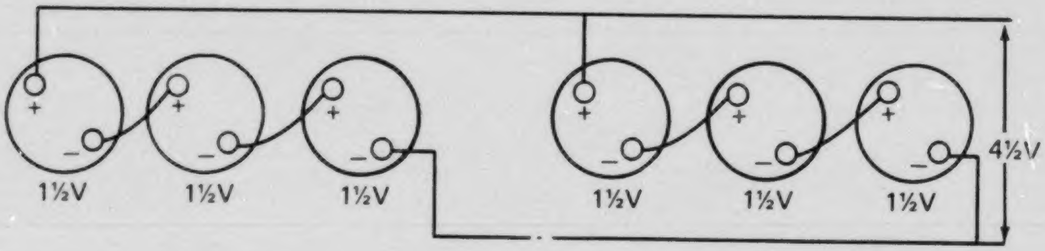
1.



2.



3.



GENERATORS AND BATTERIES
UNIT IV

TEST

NAME ______________________________ SCORE ______________

1. Match the terms on the right to the correct definitions.

_____a. Electrical power generated by using flowing water to turn generators

_____b. Generation plant powered by steam created by oil, coal, or natural gas heat

_____c. Generation plant powered by steam created by atomic energy

_____d. Generation plant powered by a diesel-fueled engine

_____e. Alternating current generator which produces current by rotating a magnetic field close to stator coil

_____f. Alternator which produces four or more voltage peaks at different intervals in time in one cycle

_____g. Sulfuric acid used in lead-acid storage batteries

_____h. Weight of electrolyte as compared to water

_____i. Instrument used to measure the specific gravity of electrolyte in a lead-acid storage battery

_____j. Electricity-producing cell which is of no value when the electrical activity is exhausted

_____k. Electricity-producing cell which can be restored to activity by passing a current through it in a reverse direction

_____l. Device which converts alternating current to direct current

_____m. Machine that converts mechanical energy to electrical energy

_____n. Two or more primary or secondary cells connected electrically

1. Diesel plant
2. Electrolyte
3. Steam plant
4. Hydroelectric power
5. Atomic plant
6. Secondary cell
7. Hydrometer
8. Primary cell
9. Rectifier
10. Specific gravity
11. Generator
12. Polyphase alternator
13. Battery
14. Alternator

2. List four kinds of generating plants.

a. ______________________________

b. ______________________________

c. ______________________________

d. ______________________________

3. Match the kinds of generators on the right to the voltages produced by each.

______a. 13,800 to 18,000 volts	1. Diesel-powered plant
______b. 120 to 480 volts	2. Gasoline-powered portable generator
______c. 1600 to 2400 volts	3. Steam and hydroelectric plants

4. Match the generators on the right to the specific use.

______a. Supplies power to large areas	1. Gasoline-powered mobile or stationary generator
______b. Supplies power to small towns or supplements larger plants during peak loads	2. Diesel-powered plant
______c. Supplies emergency or standby power for farms and businesses	3. Hydroelectric or steam plant
______d. Supplies temporary power for construction sites for power tools and lighting	4. Gasoline-powered portable generator

5. Calculate the frequency of the following generators.

______a. 2 pole generator turning 3600 rpm

______b. 4 pole generator turning 1800 rpm

______c. 96 pole generator turning 75 rpm

6. List four precautions to observe with the use of portable generators.

a. ______________________________

____

b. ______________________________

____

c. ____

____

d. ____

____

7. List two kinds of voltage-producing primary cells and two kinds of secondary cells.

a. Primary cell

1)

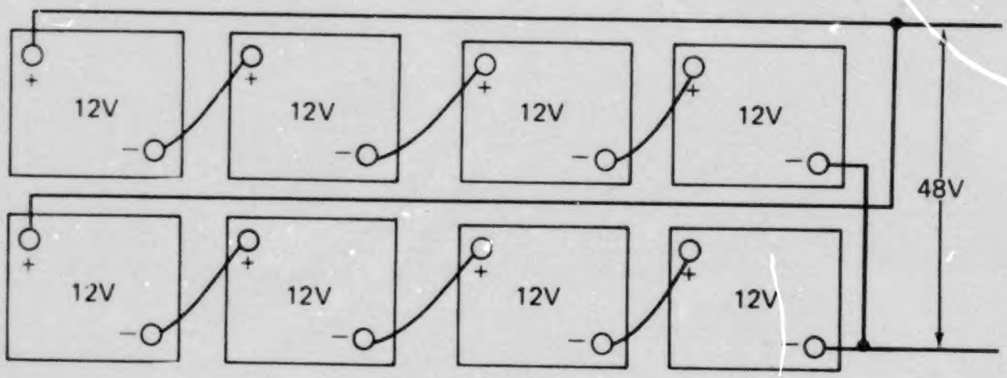
2)

b. Secondary cell

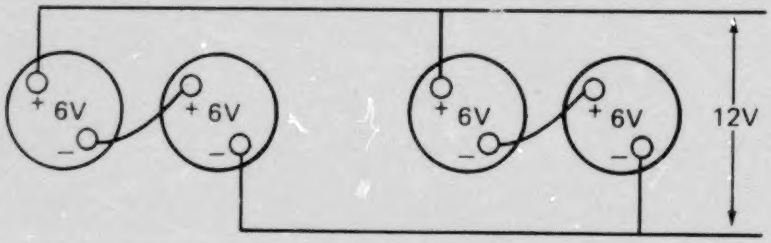
1)

2)

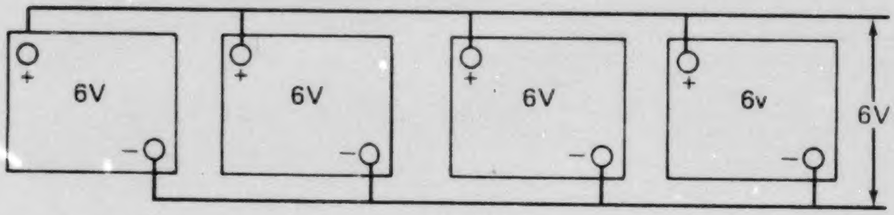
8. Identify the following types of circuits. (Answers may be used more than once.)



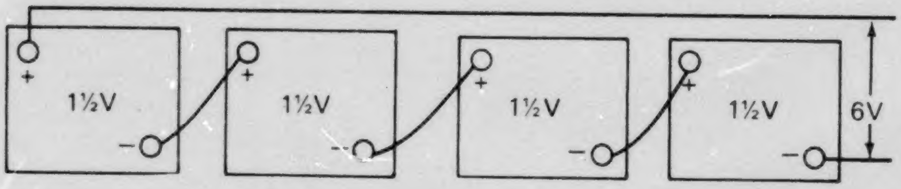
a. ____________________



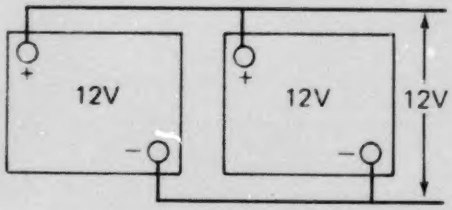
b. ____________________



c. ____________________



d. ____________________



e. ____________________

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9. Select from the list below the precautions to observe when connecting batteries. Place an "X" in the blanks provided.

_____a. Do not allow sparks or open flame near a lead-acid battery

_____b. Do not series-connect batteries unless the voltage desired is more than the voltage of one battery

_____c. Check battery by placing jumper across terminals

_____d. Wear eye protection

_____e. Do not short-circuit a battery

_____f. Store batteries on concrete floor

10. Arrange in order the following steps to follow when connecting lead-acid batteries when starting equipment.

_____a. Connect jumper to negative terminal of charged battery

_____b. Connect jumper to positive terminal of each battery

_____c. Connect other end of jumper to the frame of equipment being started

11. Connect batteries in series and parallel.

(NOTE: If this activity has not been accomplished prior to the test, ask the instructor when it should be completed.)

GENERATORS AND BATTERIES
UNIT IV

ANSWERS TO TEST

1. Match the terms on the right to the correct definitions.

__4__ a. Electrical power generated by using flowing water to turn generators

__3__ b. Generation plant powered by steam created by oil, coal, or natural gas heat

__5__ c. Generation plant powered by steam created by atomic energy

__1__ d. Generation plant powered by a diesel-fueled engine

__14__ e. Alternating current generator which produces current by rotating a magnetic field close to stator coil

__12__ f. Alternator which produces four or more voltage peaks at different intervals in time in one cycle

__2__ g. Sulfuric acid used in lead-acid storage batteries

__10__ h. Weight of electrolyte as compared to water

__7__ i. Instrument used to measure the specific gravity of electrolyte in a lead-acid storage battery

__8__ j. Electricity-producing cell which is of no value when the electrical activity is exhausted

__6__ k. Electricity-producing cell which can be restored to activity by passing a current through it in a reverse direction

__9__ l. Device which converts alternating current to direct current

__11__ m. Machine that converts mechanical energy to electrical energy

__13__ n. Two or more primary or secondary cells connected electrically

1. Diesel plant
2. Electrolyte
3. Steam plant
4. Hydroelectric power
5. Atomic plant
6. Secondary cell
7. Hydrometer
8. Primary cell
9. Rectifier
10. Specific gravity
11. Generator
12. Polyphase alternator
13. Battery
14. Alternator

2. List four kinds of generating plants.

   a. Hydroelectric

   b. Steam-powered

   c. Diesel-powered

   d. Gasoline-powered

3. Match the kinds of generators on the right to the voltages produced by each.

   __3__ a. 13,800 to 18,000 volts

   __2__ b. 120 to 480 volts

   __1__ c. 1600 to 2400 volts

   1. Diesel-powered plant

   2. Gasoline-powered portable generator

   3. Steam and hydroelectric plants

4. Match the generators on the right to the specific use.

   __3__ a. Supplies power to large areas

   __2__ b. Supplies power to small towns or supplements larger plants during peak loads

   __1__ c. Supplies emergency or standby power for farms and businesses

   __4__ d. Supplies temporary power for construction sites for power tools and lighting

   1. Gasoline-powered mobile or stationary generator

   2. Diesel-powered plant

   3. Hydroelectric or steam plant

   4. Gasoline-powered portable generator

5. Calculate the frequency of the following generators.

   __60__ a. 2 pole generator turning 3600 rpm

   __60__ b. 4 pole generator turning 1800 rpm

   __60__ c. 96 pole generator turning 75 rpm

6. List four precautions to observe with the use of portable generators.

   a. Ground the generator housing

   b. Use a three-wire power cord with ground wire (120 V supply)

   c. Check all standby generators for live connections

   d. Do not connect a generator to an energized line

7. List two kinds of voltage-producing primary cells and two kinds of secondary cells.

   a. Primary cell

      1) Zinc-carbon

      2) Mercury-zinc

   b. Secondary cell

      1) Lead-acid

      2) Nickel-cadium

8. Identify the following types of circuits.

   a. Series-parallel connected

   b. Series-parallel connected

   c. Parallel connected

   d. Series connected

   e. Parallel connected

9. Select from the list below the precautions to observe when connecting batteries. Place an "X" in the blanks provided.

   __X__ a. Do not allow sparks or open flame near a lead-acid battery

   __X__ b. Do not series-connect batteries unless the voltage desired is more than the voltage of one battery

   _____ c. Check battery by placing jumper across terminals

   __X__ d. Wear eye protection

   __X__ e. Do not short-circuit a battery

   _____ f. Store batteries on concrete floor

10. Arrange in order the following steps to follow when connecting lead-acid batteries when starting equipment.

    __2__ a. Connect jumper to negative terminal of charged battery

    __1__ b. Connect jumper to positive terminal of each battery

    __3__ c. Connect other end of jumper to the frame of equipment being started

11. Connect batteries in series and parallel.

    (NOTE: This activity will be evaluated to the satisfaction of the instructor.)

WORK PROCEDURES
(NONENERGIZED)
UNIT V

UNIT OBJECTIVE

After completion of this unit, the student should be able to arrange in order the procedure for line construction and be able to read a staking sheet. The student should be able to list materials needed to complete a work order and locate rural property using a legal description. This knowledge will be evidenced by scoring 85 percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms associated with work procedures to the correct definitions.
2. Select from a list information found on a staking sheet.
3. Arrange in order the procedure for line construction.
4. List steps to follow when installing service wire.
5. State procedure for connecting service wire.
6. Match various primary assemblies to the materials needed.
7. List materials needed to install various pole ground assemblies.
8. List materials needed for various primary assemblies.
9. List materials needed to complete a work order.
10. Identify section numbers within a township.
11. Locate rural property using legal descriptions.

WORK PROCEDURES
(NONENERGIZED)
UNIT V

SUGGESTED ACTIVITIES

I. Suggested activities for instructor:

   A. Provide student with objective sheet.

   B. Provide student with information and assignment sheets.

   C. Provide student with specifications for 7.2/12.5 kV line construction.

   D. Make transparencies.

   E. Discuss unit and specific objectives.

   F. Discuss information and assignment sheets.

   G. Discuss staking sheet used by local organization.

   H. Use local area maps for areas not in Oklahoma.

   I. Give test.

II. Unit references:

   A. Rural Electrification Administration. *Specifications and Drawings for 7.2/12.5 Kv. Line Construction*. REA Form 804. Washington, D.C.: U.S. Department of Agriculture, 1962.

   B. Rural Electrification Administration. *Specifications and Drawings for 14.4/24.9 Kv. Line Construction*. REA Form 803. Washington, D.C.: U.S. Department of Agriculture, 1969.

   C. Kurtz, Edwin B., and Shoemaker, Thomas M. *The Lineman's and Cableman's Handbook*. 5th ed. New York: McGraw-Hill Book Co., 1976.

WORK PROCEDURES
(NONENERGIZED)
UNIT V

INFORMATION SHEET

I. Terms and definitions (Transparencies 1 through 4)

   A. Staking sheet--Sheet which shows materials needed, location, and sketch of work to be done

   B. Ruling span--Average span plus two-thirds of the difference between the longest span and the average span

   C. Guy lead--Distance between the pole to be guyed and the anchor

   D. Township--Area six miles square which is divided into thirty-six sections (Transparency 1)

   E. Section--Area one mile square (Transparency 1)

   F. Quarter section--Area of a section one-half mile square (Transparency 1)

   G. Range--Location of a township either east or west of a principal meridian (Transparency 2)

   H. Meridian--Line running north and south through the state every twenty-four miles (Transparency 2)

   I. Principal meridian--Meridian which divides the east and west halves of the state (Transparency 4)

   J. Indian Meridian--Principal meridian in Oklahoma (Transparency 4)

   K. Legal description--Location of property according to township, range, section, and quarter section

   L. Section line--Line set at one mile intervals which runs both east and west and north and south through the state (Transparency 1)

   M. Range line--Line which runs east and west through the state every six miles (Transparency 2)

   N. Check--Area twenty-four miles square which contains sixteen townships (Transparency 3)

   O. Parallel--Line which runs east and west through the state every twenty-four miles (Transparency 2)

   P. Specification book--Materials and methods of line construction recommended by REA

INFORMATION SHEET

Q. Base line--Parallel in the southern part of the state; the south boundary of the Oklahoma panhandle counties from which ranges are measured (Transparencies 4 and 5)

(NOTE: The base line in Oklahoma runs through Duncan and Sulphur.)

R. Account number--Designation given a meter location which indicates the location according to a legal description

Example: 30-124-015

30 is the number given a particular township by the organizations. 12 is the section number in township 30. 4 is the quarter section in section 12. 015 is the specific location in quarter section 4.

II. Staking sheet information

(NOTE: Staking sheets differ in design from one organization to another, but the information shown is basically the same.)

A. Location

1. Range
2. Township
3. Section
4. Approximate location in section

B. Sketch of line

1. Take-off pole
2. Direction to build line
3. Dead-end pole
4. Service location

C. Pole numbers

D. Span lengths

1. Primary line
2. Secondary line
3. Service line
4. Total length of line

INFORMATION SHEET

- E. Heights and classes of poles
- F. Primary assemblies
- G. Size and type of primary conductor
- H. Right-of-way to be cleared
- I. Transformer type and size
- J. Grounding assemblies
- K. Types and sizes of guys and anchors
- L. Service size and length
- M. Secondary assemblies
- N. Miscellaneous assemblies

  Examples: Meter loop, guy guard, armor rod

- O. Size and type of meter
- P. Recap of all materials needed

  (NOTE: Any changes made in the job construction should be noted on the staking sheet.)

III. Procedure for line construction

- A. Inspect vehicle
- B. Get job assignment
- C. Read staking sheets
- D. Gather materials

  Examples: Poles, crossarms, hardware, conductor, transformers

- E. Load poles and conductor

  (NOTE: When loading poles, arrange the loading so that the poles to be unloaded first are on top.)

- F. Haul and place poles near line stakes

  (NOTE: Place poles so they will not obstruct the path of hole digging and pole setting equipment.)

INFORMATION SHEET

G. Frame poles

(NOTE: Install all hardware, crossarms, and pole grounds according to REA specifications for the unit being framed.)

H. Dig holes for poles and anchors

I. Set and tamp poles and anchors

(NOTE: Poles and anchors should be well tapped. Poles should be banked with eight to ten inches of backfill.)

J. Pull and make up guys

K. String conductor along pole line

(NOTE: Keep conductors separated when stringing to avoid tangling.)

L. Lay up conductor, sag, and tie in

(NOTE: If line being built takes off from an energized pole, deadend and ground conductor on energized pole before pulling wire to sag from other end of line.)

M. Hang transformers

(NOTE: Record information from transformer nameplate.)

N. Connect grounds and service wire

O. Remove ground cables and energize line

P. Check voltage at meter base

Q. Set meter and record information

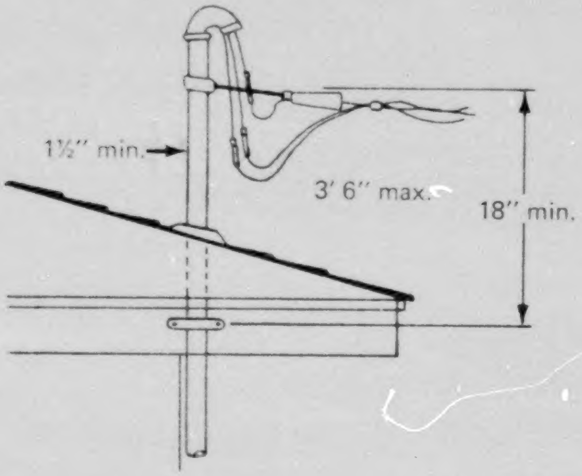
R. Sign or initial staking sheet

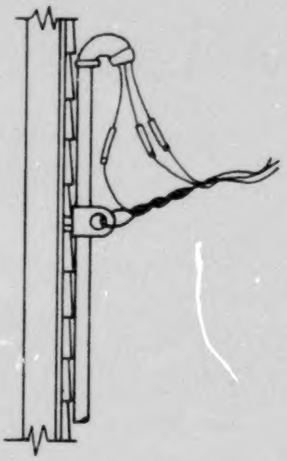
(NOTE: Pick up any wire or trash before leaving.)

INFORMATION SHEET

IV. Steps to follow when installing service wire

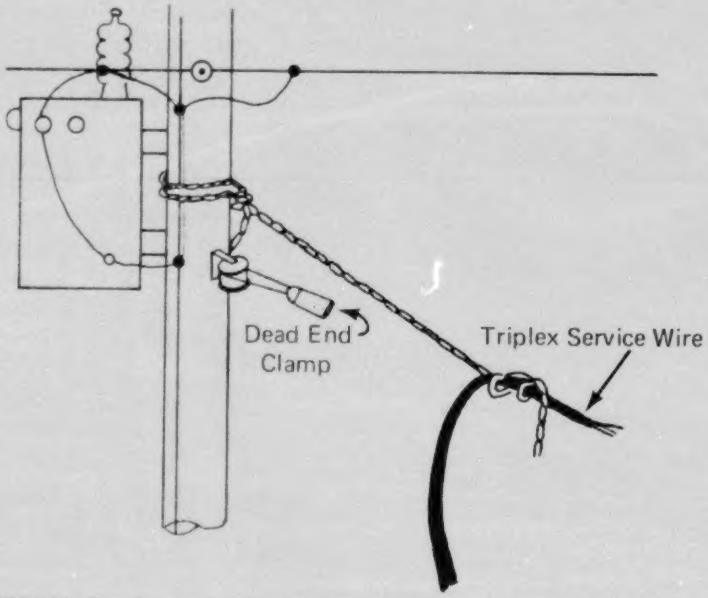
A. Attach service to house or building and connect service to consumer's meter loop





B. Pull service wire from transformer pole

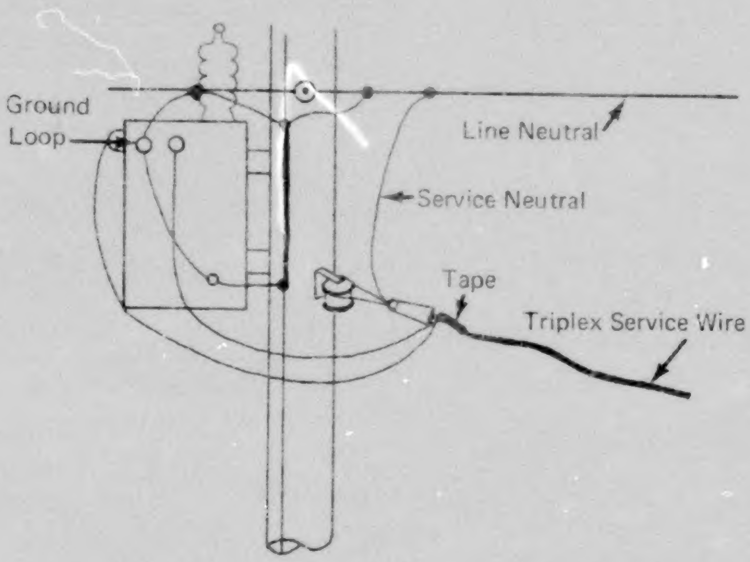
(NOTE: If service is to be connected to a meter pole, a handline should be used to pull service wire to sag on the meter pole.)



(CAUTION: Service wire should be cut as close to needed length as possible because a long wire end could flop into an energized line.)

INFORMATION SHEET

C. Place neutral wire in dead-end clamp and adjust service wire to proper sag



D. Connect service neutral to line neutral

E. Connect insulated service conductors to transformer lugs

(NOTE: Be sure the tank and secondary bushing lugs are tight and that a good ground has been made on the transformer ground loop.)

V. Procedure for connecting service wire

A. Use connector suitable for type of conductors being connected

(NOTE: Use compression type connectors when possible.)

B. Connect grounding conductors before connecting current-carrying conductors

C. Remove enough insulation to prevent connector from overlapping insulation

(NOTE: When a connector is placed over a fragment of insulation, a poor connection will result.)

D. Use inhibitor on all aluminum or aluminum to copper connections

INFORMATION SHEET

VI. Materials needed to construct primary and neutral assemblies using ACSR conductor 7.2 kV construction

A. A1

1. Pin type insulator
2. Spool insulator
3. 20" pole top pin
4. Single upset bolt
5. 5/8" machine bolts
6. 2 1/4" square washers
7. Locknuts

B. A1-1

1. Pin type insulators
2. Spool insulator
3. 20" pole top pins
4. Single upset bolt
5. 5/8" machine bolts
6. 3/4" x 1 1/2" pipe spacers
7. 2 1/4" square washers
8. Locknuts

C. A3

1. 2 1/4" square washers
2. Suspension insulators
3. 5/8" eye bolts
4. Anchor shackle
5. Primary angle assembly
6. Neutral angle assembly

INFORMATION SHEET

D. A5

1. 2 1/4" square washers
2. Suspension insulators
3. 5/8" eye bolt
4. Primary dead-end assembly
5. Neutral dead-end assembly
6. Locknuts

E. A5-2

1. 2 1/4" square washers
2. Suspension insulator
3. 5/8" eye bolt
4. Connectors
5. 5/8" eye nut
6. Jumper
7. Primary dead-end assembly
8. Neutral dead-end assembly
9. Anchor shackle
10. Locknuts

F. Primary dead-end assembly

1. Dead-end clamp
2. Armor tape

   (NOTE: Armor tape is not required if dead-end clamp is aluminum or has an aluminum liner.)

G. Neutral dead-end assembly

1. Swinging secondary clevis
2. Spool insulator
3. Loop dead-end clamp
4. Armor tape

INFORMATION SHEET

H. Neutral angle assembly
    1. Swinging secondary clevis
    2. Spool insulator

VII. Materials needed to install pole ground assemblies

A. M2-2
    1. No. 6 or equivalent soft-drawn copper
    2. Connectors
    3. Steeples
    4. Butt plate or butt wrap
    5. Galvanized nails for butt plate

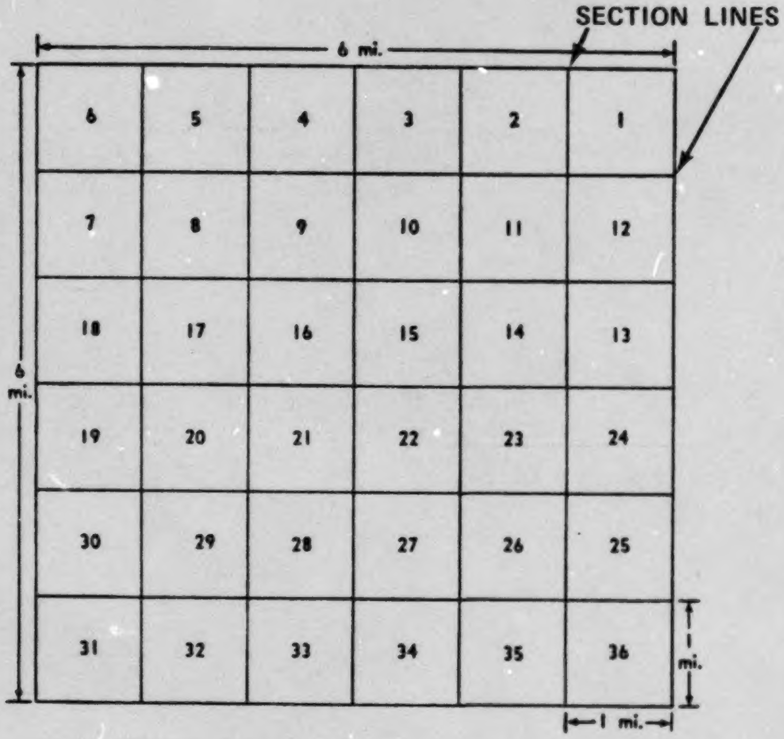
B. M2-1
    1. No. 6 or equivalent soft-drawn copper
    2. Connectors
    3. Steeples
    4. Ground rod
    5. Ground rod clamp

C. VM2-12
    1. No. 6 or equivalent soft-drawn copper
    2. Connectors
    3. Staples
    4. Butt plate or butt wrap
    5. Galvanized nails for butt plate

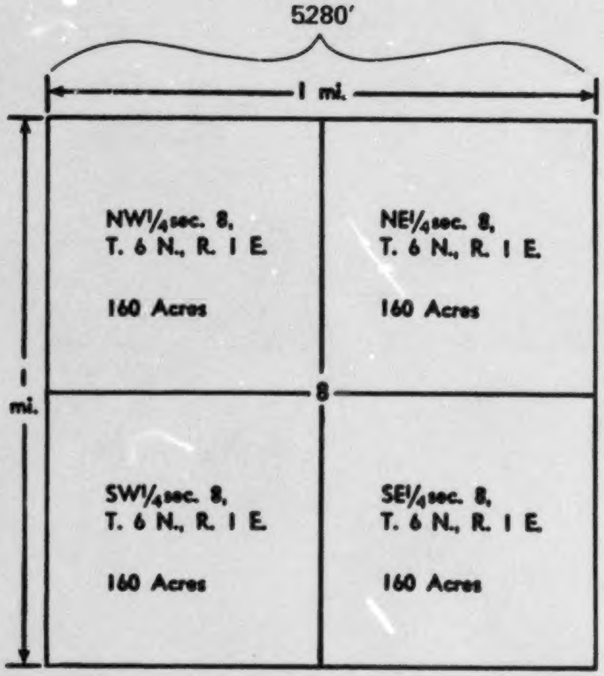
(NOTE: On 14.4 kV structures the ground wire does not extend above the neutral.)

Township And Sections

DIVISION OF TOWNSHIP INTO SECTIONS

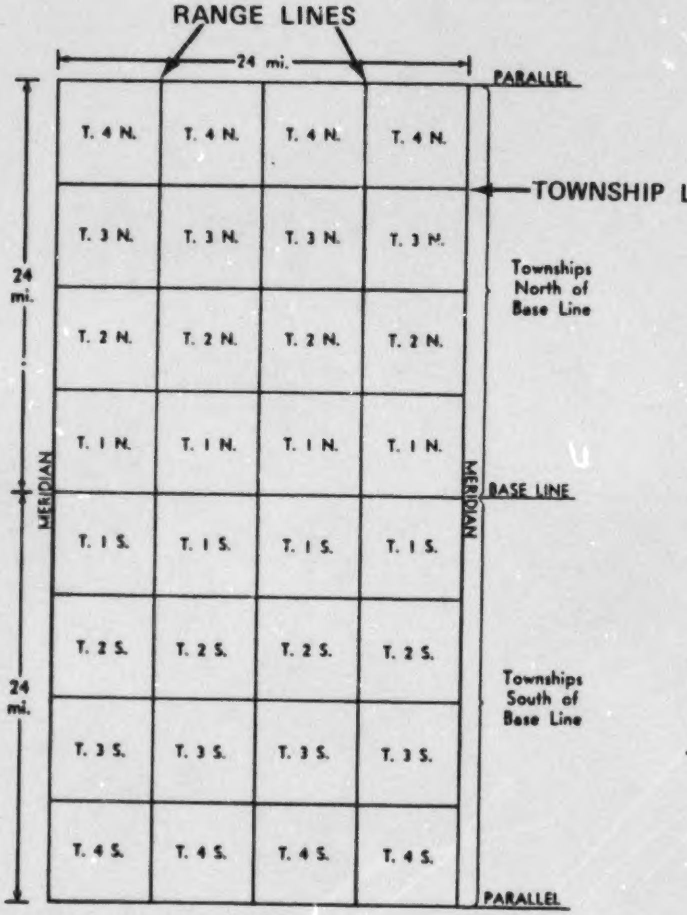


THE SECTIONS IN EACH TOWNSHIP ARE NUMBERED IN THE SAME MANNER


5280′
1 mi.
1 mi.
NW¼ sec. 8, T. 6 N., R. 1 E.
160 Acres
NE¼ sec. 8, T. 6 N., R. 1 E.
160 Acres
8
SW¼ sec. 8, T. 6 N., R. 1 E.
160 Acres
SE¼ sec. 8, T. 6 N., R. 1 E.
160 Acres

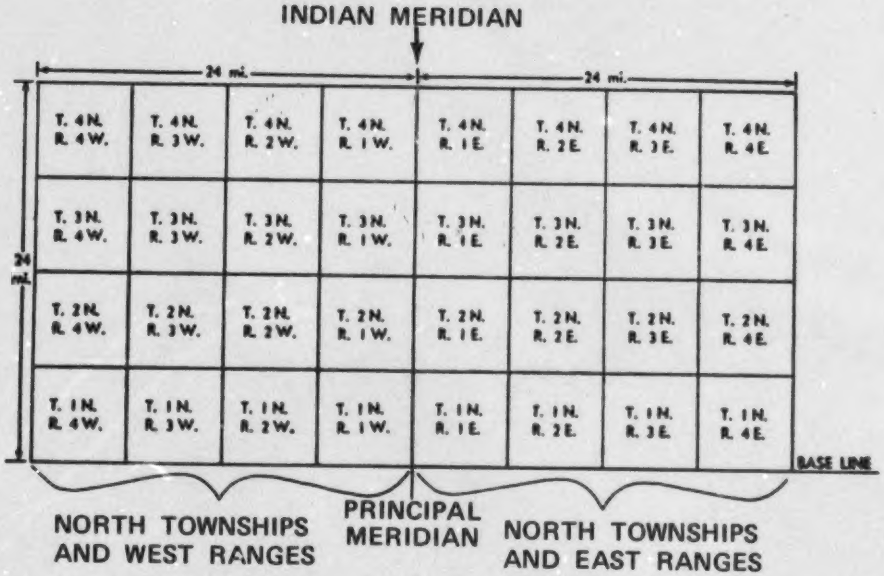
A SECTION DIVIDED INTO FOUR QUARTERS

Parallels, Meridians, And Ranges



T. 4 N.	T. 4 N.	T. 4 N.	T. 4 N.
T. 3 N.	T. 3 N.	T. 3 N.	T. 3 N.
T. 2 N.	T. 2 N.	T. 2 N.	T. 2 N.
T. 1 N.	T. 1 N.	T. 1 N.	T. 1 N.
T. 1 S.	T. 1 S.	T. 1 S.	T. 1 S.
T. 2 S.	T. 2 S.	T. 2 S.	T. 2 S.
T. 3 S.	T. 3 S.	T. 3 S.	T. 3 S.
T. 4 S.	T. 4 S.	T. 4 S.	T. 4 S.

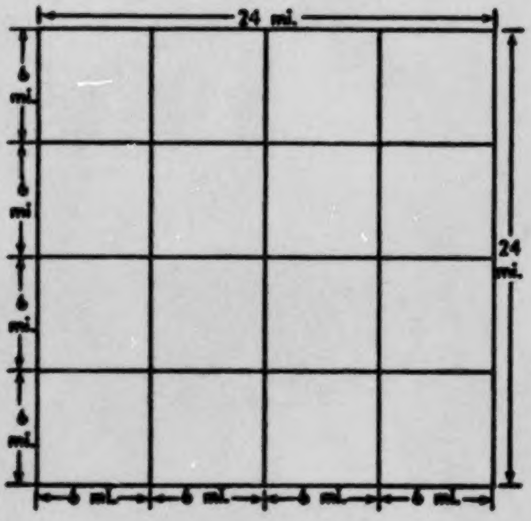
TOWNSHIPS NORTH AND SOUTH OF THE BASE LINE


INDIAN MERIDIAN
24 mi.
24 mi.
24 mi.
BASE LINE
NORTH TOWNSHIPS AND WEST RANGES
PRINCIPAL MERIDIAN
NORTH TOWNSHIPS AND EAST RANGES

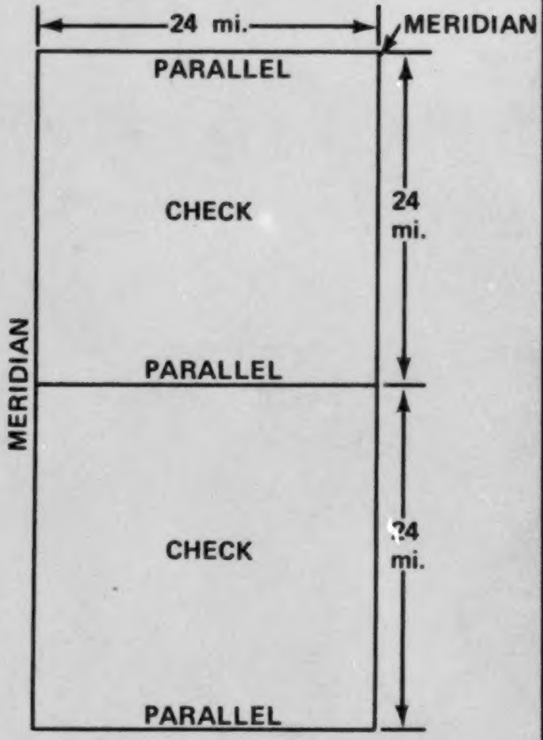
T. 4N. R. 4W.	T. 4N. R. 3W.	T. 4N. R. 2W.	T. 4N. R. 1W.	T. 4N. R. 1E.	T. 4N. R. 2E.	T. 4N. R. 3E.	T. 4N. R. 4E.
T. 3N. R. 4W.	T. 3N. R. 3W.	T. 3N. R. 2W.	T. 3N. R. 1W.	T. 3N. R. 1E.	T. 3N. R. 2E.	T. 3N. R. 3E.	T. 3N. R. 4E.
T. 2N. R. 4W.	T. 2N. R. 3W.	T. 2N. R. 2W.	T. 2N. R. 1W.	T. 2N. R. 1E.	T. 2N. R. 2E.	T. 2N. R. 3E.	T. 2N. R. 4E.
T. 1N. R. 4W.	T. 1N. R. 3W.	T. 1N. R. 2W.	T. 1N. R. 1W.	T. 1N. R. 1E.	T. 1N. R. 2E.	T. 1N. R. 3E.	T. 1N. R. 4E.

TOWNSHIPS SOUTH OF THE BASE ARE SOUTH TOWNSHIPS

Checks

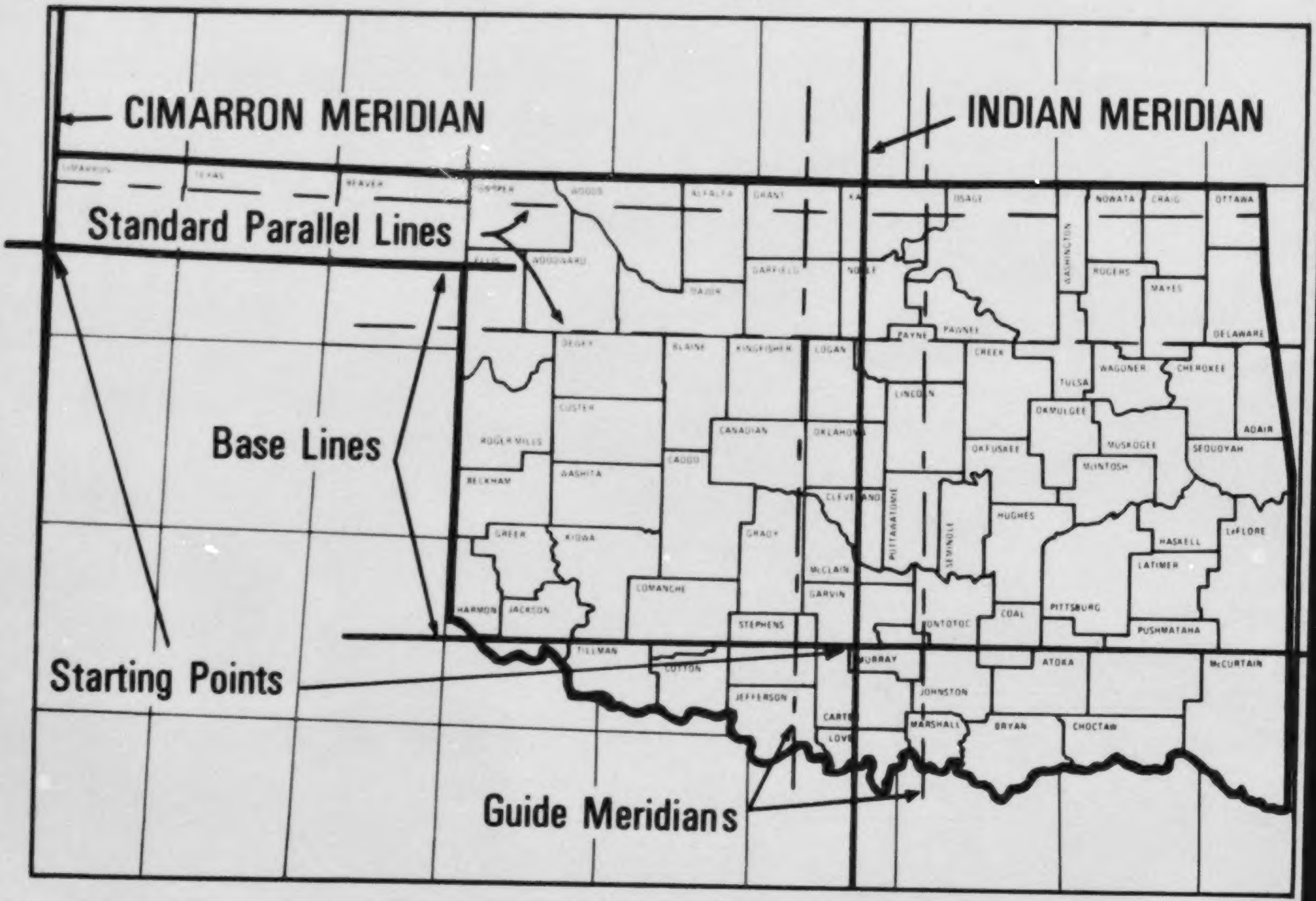


DIVISION OF A CHECK INTO SIXTEEN TOWNSHIPS

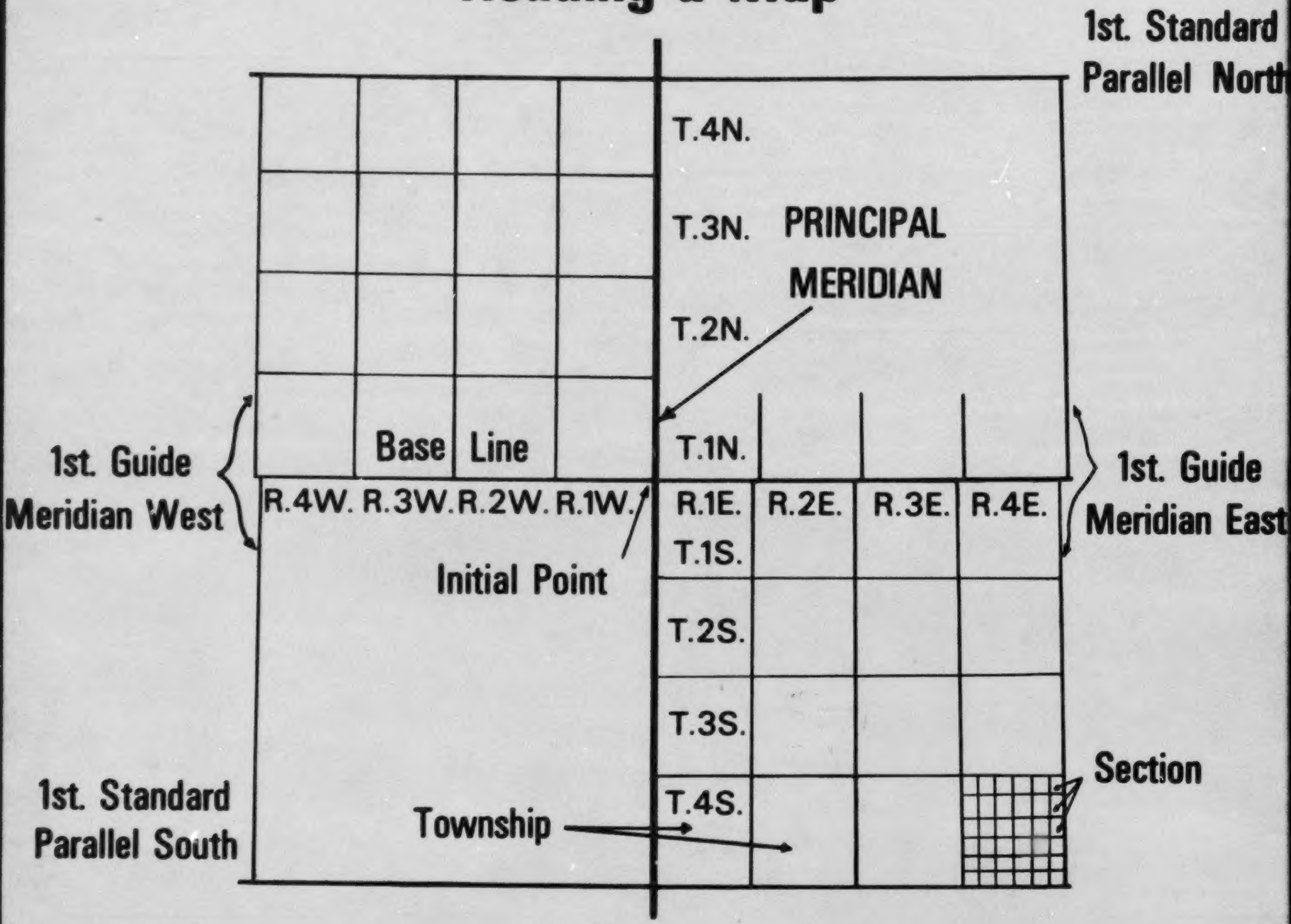


CHECKS, PARALLELS, AND MERIDIANS

Principal Meridians and Base Lines in Oklahoma



Reading a Map



WORK PROCEDURES
(NONENERGIZED)
UNIT V

ASSIGNMENT SHEET #1--LIST MATERIALS NEEDED FOR PRIMARY ASSEMBLIES

List the amount and type of hardware required to construct the following units. Use the specifications for 7.2/12.5 kV line construction.

		AMOUNT	TYPE
1.	A1		
a.	Bolts		
b.	Insulators		
c.	Insulators		
d.	Washers		
e.	Nuts		
f.	Bolts		
g.	Pins		
2.	A1-1		
a.	Bolts		
b.	Insulators		
c.	Insulators		
d.	Washers		
e.	Nuts		
f.	Bolts		
g.	Pins		
h.	Spacers		

ASSIGNMENT SHEET #1

		AMOUNT	TYPE
3.	A3		
a.	Bolts		
b.	Insulators		
c.	Insulators		
d.	Washers		
e.	Nuts		
f.	Shackle		
g.	Assembly		
h.	Assembly		
4.	A5		
a.	Bolts		
b.	Insulators		
c.	Insulators		
d.	Washers		
e.	Nuts		
f.	Assembly		
g.	Assembly		

WORK PROCEDURES
(NONENERGIZED)
UNIT V

ASSIGNMENT SHEET #2--LIST MATERIALS NEEDED TO COMPLETE A WORK ORDER

Use the staking sheet to compile and list all materials needed to construct the work order.

1. Poles

Number	Size (length) and Class
______	____________________
______	____________________
______	____________________

2. Primary assemblies

Number	Unit
______	______
______	______
______	______
______	______
______	______

3. Pole grounds

Number	Unit
______	______
______	______

Approximate total feet ground wire ____________

Number of ground rods and clamps ____________

4. Primary conductor

Type	Feet
______	______

5. Service conductor

Type	Feet
______	______

ASSIGNMENT SHEET #2

6. Service assemblies

Number ______ Unit ______

7. Guys

Number ______ Unit ______

8. Anchors

Number ______ Unit ______

9. Armor rods

Number ______

10. Connectors

Number ______

11. Miscellaneous assemblies

Number ______ Unit ______

STAKING SHEET

COSMO ELECTRIC COOPERATIVE

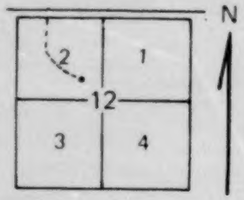
Member Joe Dokes

Work Order No 1532

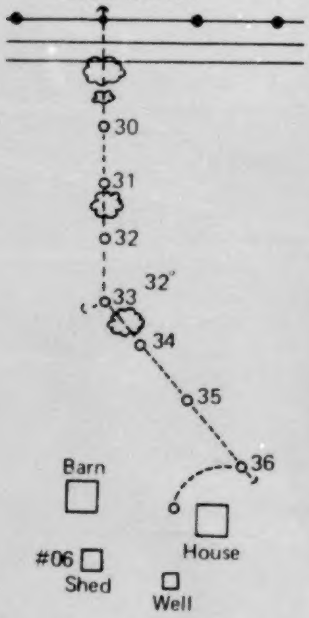
Account No 30-122-015

Sheet No 1 of 1 Sheets County Custer Township 2N Range 18W Section 12

Date Staked 7-3-77 County Custer



3051 Sketch



(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)	(J)	(K)	(L)	(M)	
Pole No.	Span	Pole H&C	Pv 1 Assm	Cond	R/W	Trans	Gvnd Assm	Guy-1 Anchor	Sec Assm	Serv	Misc Assm	Recap	
3051 "		EX 35-5	A-5-2	#4 ACSR				E1-2 F1-2				35-5	2
30	340	35-6	A-1-1		100' R120		M2-2					35-6	5
31	330	35-6	A-1				M2-2					30-6	1
32	340	35-6	A-1		60' R120		M2-1					A-1	4
33	300	35-5	A-3				M2-2	E-1 F1-2				A-1-1	1
34	300	35-6	A-1		50' R120		M2-2					A-3	1
35	270	35-6	A-1				M2-2					A-5	1
36	330	35-5	A-5			6106 25	M2-1	E1-2 F1-2		K-14		A5-2	1
												M2-2	5
MP		30-6					M2-1			60' K-14 # 2TPX	M8-9	M2-1	3
												E1-2	3
												F1-2	3
												#2TPX	60'
												#4 ACSR	4,420
												M8-9	1
												K-14	2
	2210												

ASSIGNMENT SHEET #2

Staked by Jim

Const. Started 7-7-77

Const. Completed 7-7-77

Const. Completed by D.D.

Remarks Right of way cleared by CMC 7-4-77

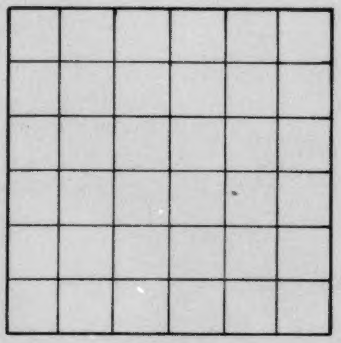
PLT - 173-C

WORK PROCEDURES
(NONENERGIZED)
UNIT V

ASSIGNMENT SHEET #3--IDENTIFY SECTION NUMBERS WITHIN A TOWNSHIP

Answer the following problems relating to the numbering of sections.

1. Number the sections within the township drawn below.



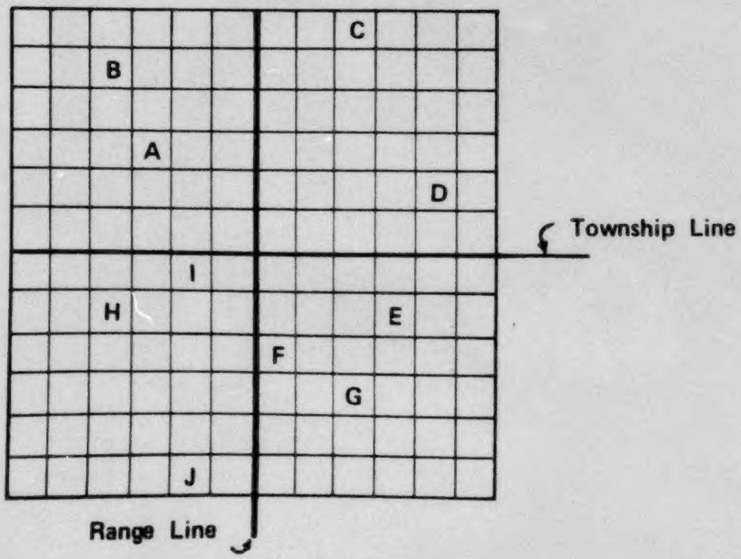
2. List the section numbers of each letter on the townships shown below.

a. ____________ e. ____________ i. ____________

b. ____________ f. ____________ j. ____________

c. ____________ g. ____________

d. ____________ h. ____________



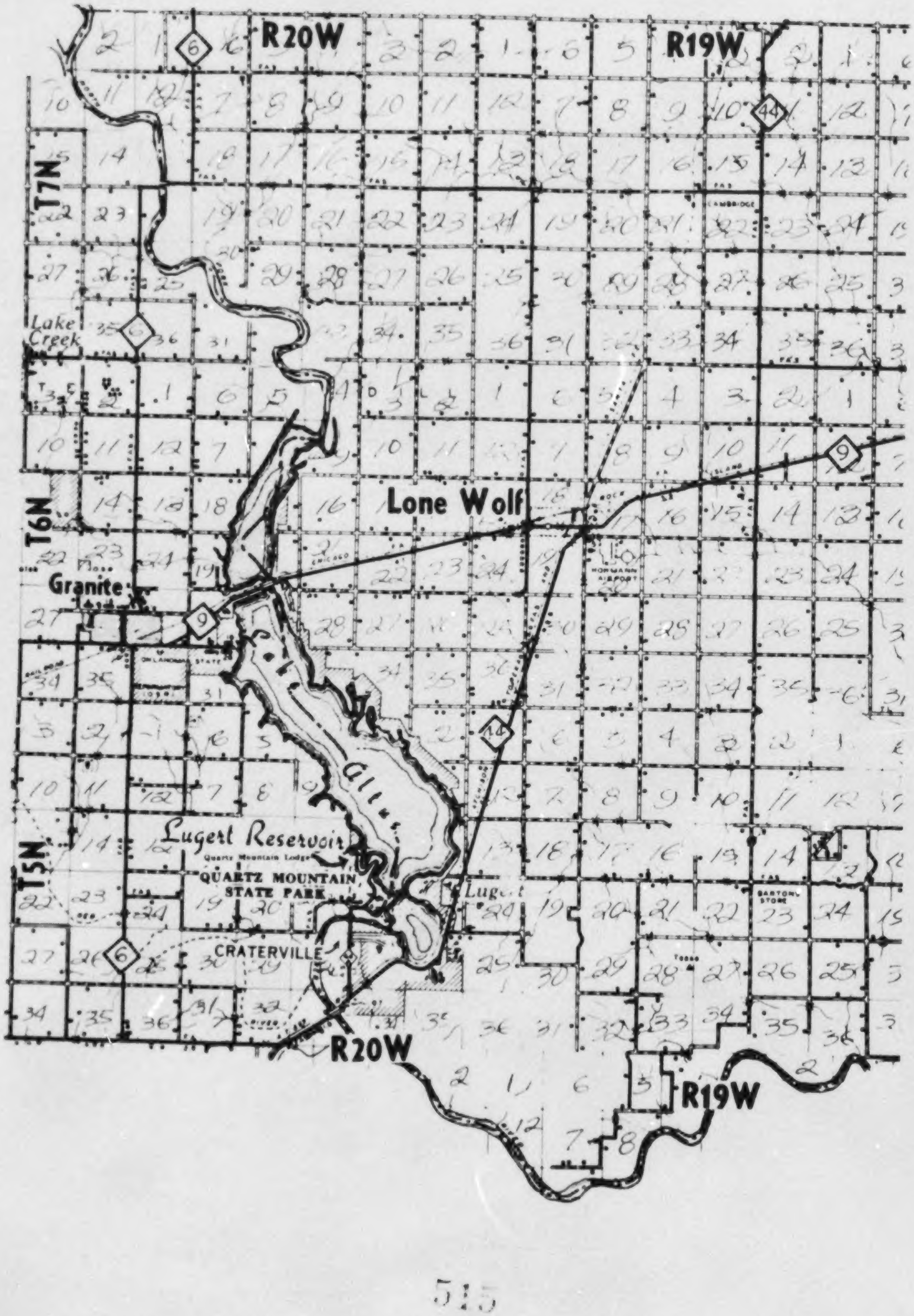
WORK PROCEDURES
(NONENERGIZED)
UNIT V

ASSIGNMENT SHEET #4--LOCATE RURAL PROPERTY IN OKLAHOMA USING LEGAL DESCRIPTIONS

Use the map on the following page to answer the questions below.

1. What is located on the following property?
   a. SEC. 20 T6N R19W ______________________
   b. SEC. 36 T6N R 21W ______________________
   c. SEC. 18 T6N R19W ______________________
2. What is the legal description for the following listed names?
   a. Cambridge ______________________
   b. Barton's Store ______________________
   c. Town of Granite ______________________
3. Approximately how many miles west of the Indian Meridian is the town of Lone Wolf?
4. Approximately how far north from the base line is the town of Granite?

ASSIGNMENT SHEET # 4



WORK PROCEDURES
(NONENERGIZED)
UNIT V

ANSWERS TO ASSIGNMENT SHEETS

Assignment Sheet #1

1. A1
   a. 2, 5/8" machine bolts
   b. 1 pin insulator
   c. 1 spool insulator
   d. 3, 2 1/4" square washers
   e. 3 locknuts
   f. 1 single upset bolt
   g. 1, 20" pole top pin
2. A1-1
   a. 2, 5/8" machine bolts
   b. 2 pin insulators
   c. 1 spool insulator
   d. 3, 2 1/4" square washers
   e. 3 locknuts
   f. 1 single upset bolt
   g. 2, 20" pole top pins
   h. 2, 3/4" pipe spacers
3. A3
   a. 2, 5/8" eye bolts
   b. 2 suspension insulators
   c. 1 spool insulator
   d. 2, 2 1/4" square washers
   e. 2 locknuts

- f. 1 anchor shackle
- g. 1 primary angle assembly
- h. 1 neutral angle assembly

4. A5
    - a. 2, 5/8" eye bolts
    - b. 2 suspension insulators
    - c. 1 spool insulator
    - d. 2, 2 1/4" square washers
    - e. 2 locknuts
    - f. 1 primary dead-end assembly
    - g. 1 neutral dead-end assembly

Assignment Sheet #2

1. Poles

Number	Size (length) and Class
2	35-5
5	35-6
1	30-6

2. Primary assemblies

Number	Unit
4	A-1
1	A1-1
1	A-3
1	A-5
1	A5-2

3. Pole grounds

Number	Unit
3	M2-1
5	M2-2

Approximate total feet ground wire--280

Number of ground rods and clamps--3

4. Primary conductor

Type	Feet
#4ACSR	4,420

5. Service conductor

Type	Feet
#2TPX	60

6. Service assemblies

Number	Unit
2	K-14

7. Guys

Number	Unit
3	E1-2

8. Anchors

Number	Unit
3	F1-2

9. Armor rods

Number
14

10. Connectors

Number
24

11. Miscellaneous assemblies

Number	Unit
1	M8-9

Assignment Sheet #3

1.

6	5	4	3	2	1
7	8	9	10	11	12
18	17	16	15	14	13
19	20	21	22	23	24
30	29	28	27	26	25
31	32	33	34	35	36

2. a. 22 c. 4 e. 10 g. 21 i. 2

b. 9 d. 26 f. 18 h. 9 j. 35

Assignment Sheet #4

1. a. Hohmann Airport

   b. Oklahoma State Reformatory

   c. Lone Wolf

2. a. Sec. 22 T7N R19W

   b. Sec. 23 T5N R19W

   c. Sec. 25 & Sec. 26 T6N R21W

3. 114 miles

4. 31 miles

WORK PROCEDURES
(NONENERGIZED)
UNIT V

TEST

NAME ______________________________ SCORE ______________

1. Match the terms on the right to the correct definitions. (Answers to "a" through "l" are on this page.)

_____a. Sheet which shows materials needed, location, and sketch of work to be done

_____b. Average span plus two-thirds of the difference between the longest span and the average span

_____c. Distance between the pole to be guyed and the anchor

_____d. Area six miles square which is divided into thirty-six sections

_____e. Area one mile square

_____f. Area of a section one-half mile square

_____g. Location of a township either east or west of a principal meridian

_____h. Line running north and south through the state every twenty-four miles

_____i. Meridian which divides the east and west halves of the state

_____j. Principle meridian in Oklahoma

_____k. Location of property according to township, range, section, and quarter section

_____l. Line set at one mile intervals which runs both east and west and north and south through the state

1. Guy lead
2. Quarter section
3. Range
4. Meridian
5. Township
6. Staking sheet
7. Ruling span
8. Principal meridian
9. Section
10. Indian Meridian
11. Section line
12. Legal description

______m. Line which runs east and west through the state every six miles

______n. Materials and methods of line construction recommended by REA

______o. Area twenty-four miles square which contains sixteen townships

______p. Line which runs east and west through the state every twenty-four miles

______q. Parallel in the southern part of the state; the south boundary of the Oklahoma panhandle counties from which ranges are measured

______r. Designation given a meter location which indicates the location according to a legal description

13. Account number
14. Parallel
15. Base line
16. Check
17. Range line
18. Specification book

2. Select from the following list the items of information found on a staking sheet by placing an "X" in the blanks.

______a. Size and type of primary conductor

______b. Span lengths

______c. Electricity rate schedule

______d. Primary assemblies

______e. Miscellaneous assemblies

______f. Pole numbers

______g. Heights and classes of poles

______h. Types and sizes of guys and anchors

______i. Secondary assemblies

______j. Recap of all materials needed

______k. Service size and length

______l. Sketch of line

______m. Location

______n. Grounding assemblies

______o. Transformer type and size

______p. Right-of-way to be cleared

______q. Size and type of meter

3. Arrange in proper order the following procedure for line construction.

_____a. Frame poles

_____b. Set and tamp poles and anchors

_____c. Get job assignment

_____d. Load poles and conductor

_____e. Pull and make up guys

_____f. Lay up conductor, sag, and tie in

_____g. Haul and place poles near line stakes

_____h. String conductor along pole line

_____i. Gather materials

_____j. Read staking sheets

_____k. Dig holes for poles and anchors

_____l. Set meter and record information

_____m. Hang transformers

_____n. Check voltage at meter base

_____o. Remove ground cables and energize line

_____p. Sign or initial staking sheet

_____q. Connect grounds and service wire

_____r. Inspect vehicle

4. List the steps to follow when installing a service wire.

a. ______________________________

____

b. ______________________________

____

c. ______________________________

____

d.

e.

5. State the procedure for connecting service wire.

a.

b.

c.

d.

6. Match the assemblies on the right to the materials needed.

_____a. Pin type insulators; spool insulator; 20" pole top pins; single upset bolt; 5/8" machine bolts; 3/4" x 1 1/2" pipe spacers; 2 1/4" square washers; locknuts

_____b. Swinging secondary clevis; spool insulator

_____c. 2 1/4" square washers; suspension insulator; 5/8" eye bolt; connectors; 5/8" eye nut; jumper; primary dead-end assembly; neutral dead-end assembly; anchor shackle; locknuts

_____d. Swinging secondary clevis; spool insulator; loop dead-end clamp; armor tape

_____e. Pin type insulator; spool insulator; 20" pole top pin; single upset bolt; 5/8" machine bolts; 2 1/4" square washers; locknuts

_____f. 2 1/4" square washers; suspension insulators; 5/8" eye bolts; anchor shackle; primary angle assembly; neutral angle assembly

_____g. Dead-end clamp; armor tape

_____h. 2 1/4" square washers; suspension insulators; 5/8" eye bolt; primary dead-end assembly; neutral dead-end assembly; locknuts

1. Neutral dead-end assembly
2. A5
3. A1-1
4. A5-2
5. Primary dead-end assembly
6. A3
7. A1
8. Neutral angle assembly

7. List the materials needed to install the pole ground assemblies listed below.

a. VM2-12

1) ______________________________

2) ______________________________

3) ______________________________

4) ______________________________

5) ______________________________

b. M2-1

1) ____________________

2) ____________________

3) ____________________

4) ____________________

5) ____________________

8. List materials needed for various primary assemblies.

9. List materials needed to complete a work order.

10. Identify section numbers within a township.

11. Locate rural property using legal descriptions.

(NOTE: If activities 8-11 have not been accomplished prior to the test, ask the instructor when they should be completed.)

WORK PROCEDURES
(NONENERGIZED)
UNIT V

ANSWERS TO TEST

1. Match the terms on the right to the correct definitions. (Answers to "a" through "l" are on this page.)

6 a. Sheet which shows materials needed, location, and sketch of work to be done

7 b. Average span plus two-thirds of the difference between the longest span and the average span

1 c. Distance between the pole to be guyed and the anchor

5 d. Area six miles square which is divided into thirty-six sections

9 e. Area one mile square

2 f. Area of a section one-half mile square

3 g. Location of a township either east or west of a principle meridian

4 h. Line running north and south through the state every twenty-four miles

8 i. Meridian which divides the east and west halves of the state

10 j. Principle meridian in Oklahoma

12 k. Location of property according to township, range, section, and quarter section

11 l. Line set at one mile intervals which runs both east and west and north and south through the state

1. Guy lead
2. Quarter section
3. Range
4. Meridian
5. Township
6. Staking sheet
7. Ruling span
8. Principal meridian
9. Section
10. Indian Meridian
11. Section line
12. Legal description

17 m. Line which runs east and west through the state every six miles

18 n. Materials and methods of line construction recommended by REA

16 o. Area twenty-four miles square which contains sixteen townships

14 p. Line which runs east and west through the state every twenty-four miles

15 q. Parallel in the southern part of the state; the south boundary of the Oklahoma panhandle counties from which ranges are measured

13 r. Designation given a meter location which indicates the location according to a legal description

13. Account number
14. Parallel
15. Base line
16. Check
17. Range line
18. Specification book

2. Select from the following list the items of information found on a staking sheet by placing an "X" in the blanks.

X a. Size and type of primary conductor

X b. Span lengths

____ c. Electricity rate schedule

X d. Primary assemblies

X e. Miscellaneous assemblies

X f. Pole numbers

X g. Heights and classes of poles

X h. Types and sizes of guys and anchors

X i. Secondary assemblies

X j. Recap of all materials needed

X k. Service size and length

X l. Sketch of line

X m. Location

X n. Grounding assemblies

X o. Transformer type and size

X p. Right-of-way to be cleared

X q. Size and type of meter

3. Arrange in proper order the following procedure for line construction.

7 a. Frame poles

9 b. Set and tamp poles and anchors

2 c. Get job assignment

5 d. Load poles and conductor

10 e. Pull and make up guys

12 f. Lay up conductor, sag, and tie in

6 g. Haul and place poles near line stakes

11 h. String conductor along pole line

4 i. Gather materials

3 j. Read staking sheets

8 k. Dig holes for poles and anchors

17 l. Set meter and record information

13 m. Hang transformers

16 n. Check voltage at meter base

15 o. Remove ground cables and energize line

18 p. Sign or initial staking sheet

14 q. Connect grounds and service wire

1 r. Inspect vehicle

4. List the steps to follow when installing a service wire.

a. Attach service to house or building and connect service to consumer's meter loop

b. Pull service wire from transformer pole

c. Place neutral wire in dead-end clamp and adjust service wire to proper sag

d. Connect service neutral to line neutral

e. Connect insulated service conductors to transformer lugs

5. State the procedure for connecting service wire.

   a. Use connector suitable for type of conductors being connected

   b. Connect grounding conductors before connecting current-carrying conductors

   c. Remove enough insulation to prevent connector from overlapping insulation

   d. Use inhibitor on all aluminum or aluminum to copper connections

6. Match the assemblies on the right to the materials needed.

3 a. Pin type insulators; spool insulator; 20" pole top pins; single upset bolt; 5/8" machine bolts; 3/4" x 1 1/2" pipe spacers; 2 1/4" square washers; locknuts

8 b. Swinging secondary clevis; spool insulator

4 c. 2 1/4" square washers; suspension insulator; 5/8" eye bolt; connectors; 5/8" eye nut; jumper; primary dead-end assembly; neutral dead-end assembly; anchor shackle; locknuts

1 d. Swinging secondary clevis; spool insulator; loop dead-end clamp; armor tape

7 e. Pin type insulator; spool insulator; 20" pole top pin; single upset bolt; 5/8" machine bolts; 2 1/4" square washers; locknuts

6 f. 2 1/4" square washers; suspension insulators; 5/8" eye bolts; anchor shackle; primary angle assembly; neutral angle assembly

5 g. Dead-end clamp; armor tape

2 h. 2 1/4" square washers; suspension insulators; 5/8" eye bolt; primary dead-end assembly; neutral dead-end assembly; locknuts

1. Neutral dead-end assembly
2. A5
3. A1-1
4. A5-2
5. Primary dead-end assembly
6. A3
7. A1
8. Neutral angle assembly

7. List the materials needed to install the pole ground assemblies listed below.
    a. VM2-12
        1) No. 6 or equivalent soft-drawn copper
        2) Connectors
        3) Staples
        4) Butt plate or butt wrap
        5) Galvanized nails for butt plate
    b. M2-1
        1) No. 6 or equivalent soft-drawn copper
        2) Connectors
        3) Steeples
        4) Ground rod
        5) Ground rod clamp
8. List materials needed for various primary assemblies.
9. List materials needed to complete a work order.
10. Identify section numbers within a township.
11. Locate rural property using legal descriptions.

(NOTE: Activities 8-11 will be evaluated to the satisfaction of the instructor.)

INSULATION
UNIT I

UNIT OBJECTIVE

After completion of this unit, the student should be able to select from a list methods of insulating distribution voltages and transmission voltages on wooden structures. The student should be able to select from a list precautions to observe with insulators and insulation. This knowledge will be evidenced by scoring 85 percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms and definitions commonly associated with insulators and insulation.
2. List steps to follow when installing a pin type insulator.
3. Select from a list the correct methods of insulating distribution voltage.
4. Select from a list methods of insulating various transmission voltages on wooden structures.
5. Match insulative materials to the specific uses.
6. Select from a list precautions to observe with insulators and insulation.

INSULATION
UNIT I

SUGGESTED ACTIVITIES

I. Suggested activities for instructor:

   A. Provide student with objective sheet.

   B. Provide student with information sheet.

   C. Make transparencies.

   D. Discuss unit and specific objectives.

   E. Discuss information sheet.

   F. Show student films, charts, and other supplemental information on insulation.

   G. Give test.

II. Unit references:

   A. *Essex Underground Cable Engineering Handbook.* Marion, Indiana: Essex International Inc./Power Conductor Div., 1971.

   B. Kurtz, Edwin B., and Shoemaker, Thomas M. *The Lineman's and Cableman's Handbook.* 5th ed. New York: McGraw-Hill Book Co., 1976.

INSULATION
UNIT I

INFORMATION SHEET

I. Terms and definitions

A. Flashover--Arc between an energized conductor and hardware over an insulator

B. Suspension insulator--Insulator which can be joined to others to form a string of insulators (Transparency 1)

C. Post insulator--Insulator which mounts by means of a stud bolt in the base of the insulator (Transparency 2)

D. Side post insulator--Insulator which bolts to the side of a structure in a horizontal position (Transparency 3)

E. Pin insulator--Insulator which mounts on a steel pole top or crossarm pin (Transparency 4)

F. Spool insulator--Insulator which mounts on an upset bolt, with a clevis, or on a rack (Transparency 4)

G. Porcelain--Material used to make insulators; made from kaolin, quartz, and feldspar

H. Fiberglass--High strength, rigid insulative material

I. Cross-linked polyethylene (XLPE)--Tough, flexible insulation whose atoms are chemically bonded

J. Low density, high molecular weight polyethylene (HMPE)--Solid, tough, flexible insulation

K. Ethylene propylene (EP)--Thermosetting, rubber-like insulation

L. Hi-dielectric--Any substance with high resistance to current flow

M. Natural rubber--Flexible, hi-dielectric insulation

N. Molecule--Smallest element of a substance which retains its identity in a mass

O. Ozone--Gas generated from an electric arc which will destroy natural rubber

P. Basic insulation level (BIL)--Level at which insulation can withstand a voltage impulse without breaking down

(NOTE: The basic insulation level is stated in kilovolts.)

INFORMATION SHEET

II. Steps to install pin type insulator

- A. Check for cracks or chips
- B. Screw insulator onto pin
- C. Align top groove with conductor
- D. Install tie

(NOTE: Always wear gloves when handling insulators to prevent injury.)

III. Methods of insulating distribution voltage

- A. 7,200-volt dead ends and angles
  - 1. Two 4 1/4" suspension insulators
  - 2. Two 6" suspension insulators
- B. 14,400-volt dead ends and angles
  - 1. Three 4 1/4" suspension insulators
  - 2. Three 6" suspension insulators
  - 3. Two 10" suspension insulators

IV. Methods of insulating transmission voltages on wooden structures

- A. 69,000-volt vertical suspension, dead ends, and angles
  - 1. Four 10" suspension insulators on vertical suspension
  - 2. Six 10" suspension insulators on horizontal angles
  - 3. Six 10" suspension insulators on dead ends
- B. 138,000-volt vertical suspension, dead ends, and angles
  - 1. Nine 10" suspension insulators on vertical suspension
  - 2. Ten 10" suspension insulators on horizontal angles
  - 3. Eleven 10" suspension insulators on dead ends

(NOTE: An additional insulator is added on steel structures and may be added on other structures to increase clearance from the structure.)

INFORMATION SHEET

V. Insulative materials and their uses

  A. Porcelain--Used in the manufacture of pin, suspension, and bushing insulators

  B. Tempered glass--Used in the manufacture of pin and suspension insulators

  C. Fiberglass--Used in the manufacture of hot line tools, cover-up material, and hot line equipment

  D. XLPE--Used as a covering on overhead and underground low voltage cable

  E. EP--Used for cable insulation up to 35 kV

  F. HMPE--Used for cable insulation above and below 35 kV

  G. Natural rubber--Used in the manufacture of rubber gloves, rubber sleeves, and cover-up materials

VI. Precautions to observe with insulators and insulation

  A. Wear gloves when handling porcelain or glass insulators

  B. Transport insulators in cartons to avoid breakage

  C. Store rubber goods away from electrical equipment

  D. Do not fold rubber protective equipment

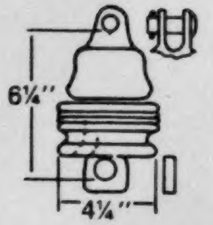
  E. Keep rubber goods away from petroleum products

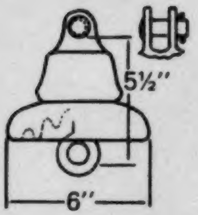
  F. Clean rubber goods often with mild detergent

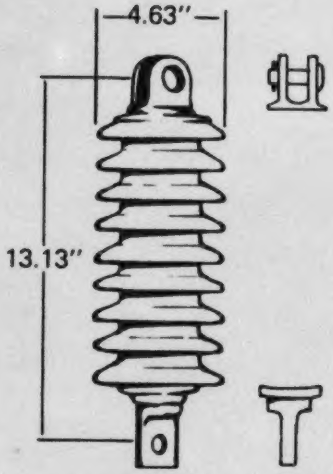
  G. Check protective and cover-up material daily for cracks, cuts, or deterioration

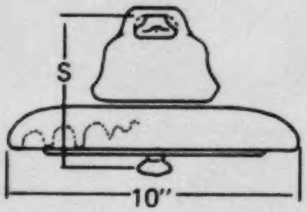
  H. Store rubber goods away from heat and sunlight

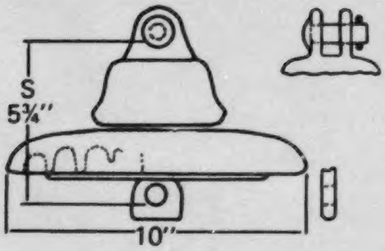
Suspension Insulators



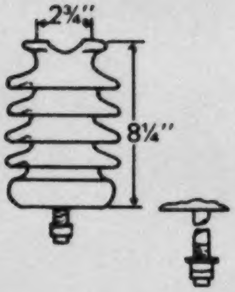




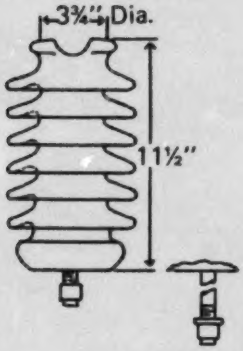




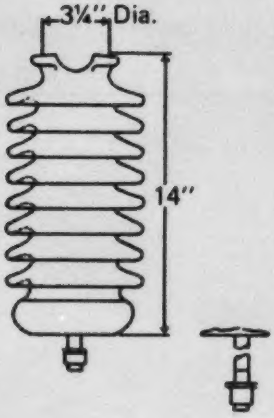
Tie Top Post Insulators



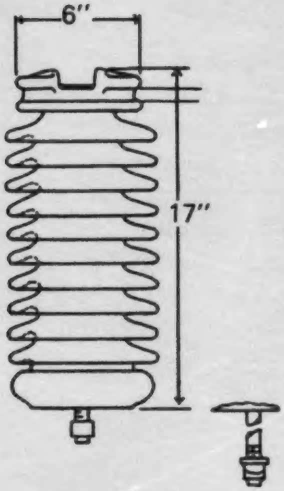
14.4 kV



34.5 kV



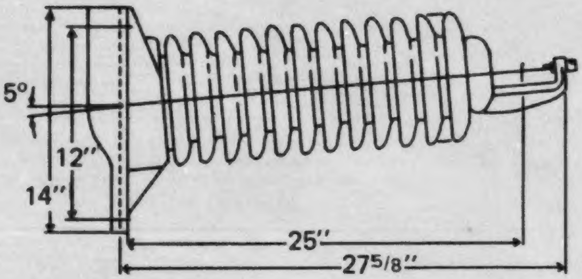
45 kV

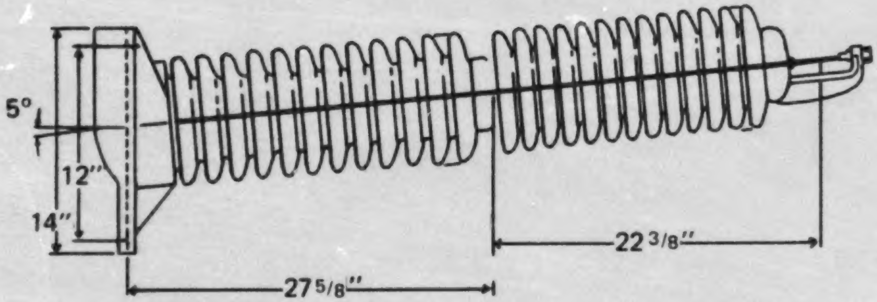


69 kV

Side Post Insulators

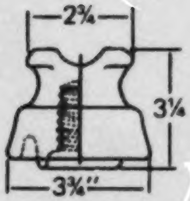
Side Post Insulator Clamp Top 69 kV

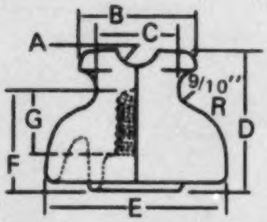




Side Post Insulator, Clamp Top 138 kV

Pin Insulator

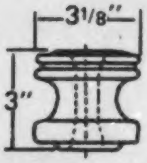


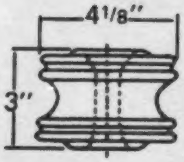


Dimensions in inches

A	B	C	D	E	F	G
9/16	3 1/8	2 1/4	3 13/16	4 7/8	2 3/4	1 3/4
1	3 3/4	2 3/4	4 1/4	4 7/8	2 7/8	1 7/8
9/16	3 1/2	2 7/8	4 1/2	5 5/8	3 1/4	2
1	4	2 7/8	4 9/16	5 5/8	2 13/16	2
9/16	4	2 7/8	5	7 1/8	3 5/16	2
1	4 1/4	2 7/8	5 1/8	7 1/8	3 5/16	2

Secondary Spool Insulator





INSULATION
UNIT I

TEST

NAME ______________________________ SCORE ____________________

1. Match the terms on the right to the correct definitions.

______a. Arc between an energized conductor and hardware over an insulator

______b. Insulator which can be joined to others to form a string of insulators

______c. Insulator which mounts by means of a stud bolt in the base of the insulator

______d. Insulator which bolts to the side of a structure in a horizontal position

______e. Insulator which mounts on a steel pole top or crossarm pin

______f. Insulator which mounts on an upset bolt, with a clevis, or on a rack

______g. Material used to make insulators; made from kaolin, quartz, and feldspar

______h. High strength, rigid insulative material

______i. Tough, flexible insulation whose atoms are chemically bonded

______j. Solid, tough, flexible insulation

______k. Thermosetting, rubber-like insulation

______l. Flexible, hi-dielectric insulation

______m. Smallest element of a substance which retains its identity in a mass

______n. Gas generated from an electric arc which will destroy natural rubber

______o. Any substance with high resistance to current flow

______p. Level at which insulation can withstand a voltage impulse without breaking down

1. Molecule
2. Fiberglass
3. Post insulator
4. Flashover
5. Natural rubber
6. Ozone
7. Low density, high molecular weight polyethylene
8. Porcelain
9. Spool insulator
10. Suspension insulator
11. Pin insulator
12. Ethylene propylene
13. Cross-linked polyethylene
14. Side post insulator
15. Basic insulation level
16. Hi-dielectric

2. List four steps to follow when installing a pin type insulator.

   a. ______________________________

   b. ______________________________

   c. ______________________________

   d. ______________________________

3. Select from the list below the methods of insulating distribution voltages by placing an "X" in the blanks.

   a. 14,400-volt dead ends and angles

      ______1) Four 4 1/4" suspension insulators

      ______2) Three 6" suspension insulators

      ______3) Two 10" suspension insulators

      ______4) Three 4 1/4" suspension insulators

   b. 7,200-volt dead ends and angles

      ______1) Three 4 1/4" suspension insulators

      ______2) Two 6" suspension insulators

      ______3) Two 4 1/4" suspension insulators

4. Select from the list below the methods of insulating the transmission voltages on wooden structures.

   a. 138,000-volt vertical suspension

      ______1) Eight 10" suspension insulators

      ______2) Nine 10" suspension insulators

   b. 138,000-volt horizontal angles

      ______1) Nine 10" suspension insulators

      ______2) Ten 10" suspension insulators

   c. 138,000-volt dead ends

      ______1) Ten 10" suspension insulators

      ______2) Eleven 10" suspension insulators

   d. 69,000-volt vertical suspension

      ______1) Six 10" suspension insulators

      ______2) Four 10" suspension insulators

e. 69,000-volt horizontal angles

______1) Six 10" suspension insulators

______2) Five 10" suspension insulators

f. 69,000-volt dead ends

______1) Five 10" suspension insulators

______2) Six 10" suspension insulators

5. Match the insulative materials on the right to their specific uses.

______a. Used in the manufacture of pin, suspension, and bushing insulators

______b. Used in the manufacture of pin and suspension insulators

______c. Used in the manufacture of hot line tools, cover-up material, and hot line equipment

______d. Used as a covering on overhead and underground low voltage cable

______e. Used for cable insulation up to 35 kV

______f. Used for cable insulation above and below 35 kV

______g. Used in the manufacture of rubber gloves, rubber sleeves, and cover-up materials

1. Fiberglass
2. HMPE
3. Natural rubber
4. EP
5. Tempered glass
6. XLPE
7. Porcelain

6. Select from the following list the precautions to observe with insulators and insulation by placing an "X" in the blanks.

______a. Keep rubber goods away from petroleum products

______b. Store rubber goods away from electrical equipment

______c. Clean rubber goods often with mild detergent

______d. Check protective and cover-up material daily for cracks, cuts, or deterioration

______e. Do not fold rubber protective equipment

______f. Wear gloves when handling porcelain or glass insulators

______g. Clean insulators daily with mild detergent

______h. Transport insulators in cartons to avoid breakage

______i. Store rubber goods away from heat and sunlight

INSULATION
UNIT I

ANSWERS TO TEST

1. Match the terms on the right to the correct definitions.

__4__ a. Arc between an energized conductor and hardware over an insulator

__10__ b. Insulator which can be joined to others to form a string of insulators

__3__ c. Insulator which mounts by means of a stud bolt in the base of the insulator

__14__ d. Insulator which bolts to the side of a structure in a horizontal position

__11__ e. Insulator which mounts on a steel pole top or crossarm pin

__9__ f. Insulator which mounts on an upset bolt, with a clevis, or on a rack

__8__ g. Material used to make insulators; made from kaolin, quartz, and feldspar

__2__ h. High strength, rigid insulative material

__13__ i. Tough, flexible insulation whose atoms are chemically bonded

__7__ j. Solid, tough, flexible insulation

__12__ k. Thermosetting, rubber-like insulation

__5__ l. Flexible, hi-dialectric insulation

__1__ m. Smallest element of a substance which retains its identity in a mass

__6__ n. Gas generated from an electric arc which will destroy natural rubber

__16__ o. Any substance with high resistance to current flow

__15__ p. Level at which insulation can withstand a voltage impulse without breaking down

1. Molecule
2. Fiberglass
3. Post insulator
4. Flashover
5. Natural rubber
6. Ozone
7. Low density, high molecular weight polyethylene
8. Porcelain
9. Spool insulator
10. Suspension insulator
11. Pin insulator
12. Ethylene propylene
13. Cross-linked polyethylene
14. Side post insulator
15. Basic insulation level
16. Hi-dialectric

2. List four steps to follow when installing a pin type insulator.
    a. Check for cracks or chips
    b. Screw insulator onto pin
    c. Align top groove with conductor
    d. Install tie

3. Select from the list below the methods of insulating distribution voltages by placing an "X" in the blanks.
    a. 14,400-volt dead ends and angles

        ______1) Four 4 1/4" suspension insulators

        __X__2) Three 6" suspension insulators

        __X__3) Two 10" suspension insulators

        __X__4) Three 4 1/4" suspension insulators

    b. 7,200-volt dead ends and angles

        ______1) Three 4 1/4" suspension insulators

        __X__2) Two 6" suspension insulators

        __X__3) Two 4 1/4" suspension insulators

4. Select from the list below the methods of insulating the transmission voltages on wooden structures.
    a. 138,000-volt vertical suspension

        ______1) Eight 10" suspension insulators

        __X__2) Nine 10" suspension insulators

    B. 138,000-volt horizontal angles

        ______1) Nine 10" suspension insulators

        __X__2) Ten 10" suspension insulators

    c. 138,000-volt dead ends

        ______1) Ten 10" suspension insulators

        __X__2) Eleven 10" suspension insulators

    d. 69,000-volt vertical suspension

        ______1) Six 10" suspension insulators

        __X__2) Four 10" suspension insulators

e. 69,000-volt horizontal angles

X 1) Six 10" suspension insulators

______ 2) Five 10" suspension insulators

f. 69,000-volt dead ends

______ 1) Five 10" suspension insulators

X 2) Six 10" suspension insulators

5. Match the insulative materials on the right to their specific uses.

7 a. Used in the manufacture of pin, suspension, and bushing insulators

5 b. Used in the manufacture of pin and suspension insulators

1 c. Used in the manufacture of hot line tools, cover-up material, and hot line equipment

6 d. Used as a covering on overhead and underground low voltage cable

4 e. Used for cable insulation up to 35 kV

2 f. Used for cable insulation above and below 35 kV

3 g. Used in the manufacture of rubber gloves, rubber sleeves, and cover-up materials

1. Fiberglass
2. HMPE
3. Natural rubber
4. EP
5. Tempered glass
6. XLPE
7. Porcelain

6. Select from the following list the precautions to observe with insulators and insulation by placing an "X" in the blanks.

X a. Keep rubber goods away from petroleum products

X b. Store rubber goods away from electrical equipment

X c. Clean rubber goods often with mild detergent

X d. Check protective and cover-up material daily for cracks, cuts, or deterioration

X e. Do not fold rubber protective equipment

X f. Wear gloves when handling porcelain or glass insulators

______ g. Clean insulators daily with mild detergent

X h. Transport insulators in cartons to avoid breakage

X i. Store rubber goods away from heat and sunlight

SUBSTATIONS
UNIT II

UNIT OBJECTIVE

After completion of this unit, the student should be able to identify and state the functions of substation components. The student should be able to select from a list precautions to observe with a substation and be able to state procedures for changing a substation oil circuit recloser and bypassing a current transformer. The student should be able to recognize indications of a problem in a substation. This knowledge will be evidenced by scoring 85 percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms commonly used with substations to the correct definitions.
2. Identify components of a substation.
3. Match components of a substation to the specific use.
4. State functions of a substation.
5. Arrange in order steps to take a substation out of service.
6. Select from a list precautions tc observe with a substation.
7. Arrange in order the correct procedure for changing a substation oil circuit recloser.
8. State the correct procedure for bypassing a substation current transformer.
9. List indications in a substation that could cause an outage.
10. Match indications to problems which may occur in substations.

SUBSTATIONS
UNIT II

SUGGESTED ACTIVITIES

I. Suggested activities for instructor:

   A. Provide student with objective sheet.

   B. Provide student with information sheet.

   C. Discuss unit and specific objectives.

   D. Discuss information sheet.

   E. Give test.

II. Unit references:

   A. Rural Electrification Administration. *Substation Inspection and Maintenance.* REA Bulletin 165-1. Washington, D.C.: U.S. Department of Agriculture, May 1956.

   B. Rural Electrification Administration. *Guide for the Design of Substations for Rural Distribution Systems.* REA Bulletin 65-1. Washington, D.C.: U.S. Department of Agriculture, July 1970.

SUBSTATIONS
UNIT II

INFORMATION SHEET

I. Terms and definitions

A. High side fuse--Fuse which protects the transmission line from a short circuit in a substation

B. Grounding grid--Buried metal mat or conductor under and around a substation

C. Station arrester--Lightning arrester designed to protect a substation transformer from high voltage surges

D. Air-break switch--Switch designed to open a circuit which is not under heavy load

E. Bypass switch--Switch designed to change current flow around a piece of equipment

F. Bus--Heavy conductor made of copper or aluminum wire or bar which distributes current in a substation

G. Oil circuit recloser--Switch which protects the substation transformer from short circuits on distribution lines

H. Bay--Section of a substation which contains one secondary three-phase circuit

I. Vacuum recloser--Switch used for heavy loads, usually above 200 amperes

INFORMATION SHEET

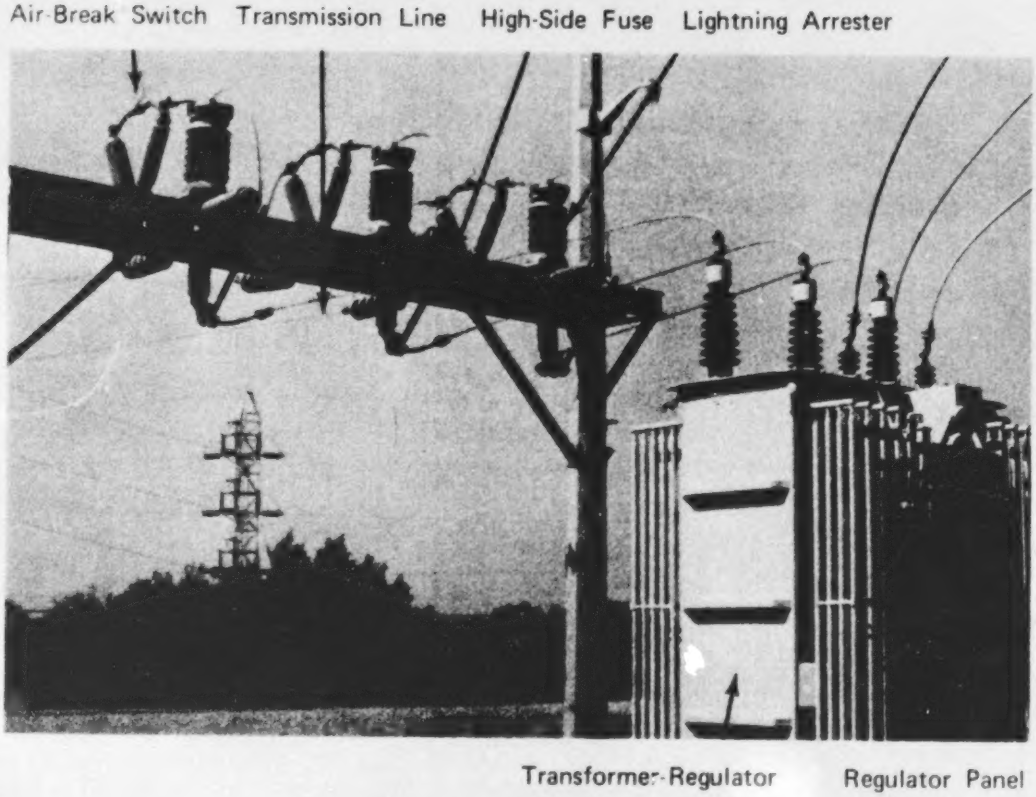
II. Components of a substation

   A. Transmission line

   B. Air-break switch (three-phase)

   C. Lightning arrester (station type)

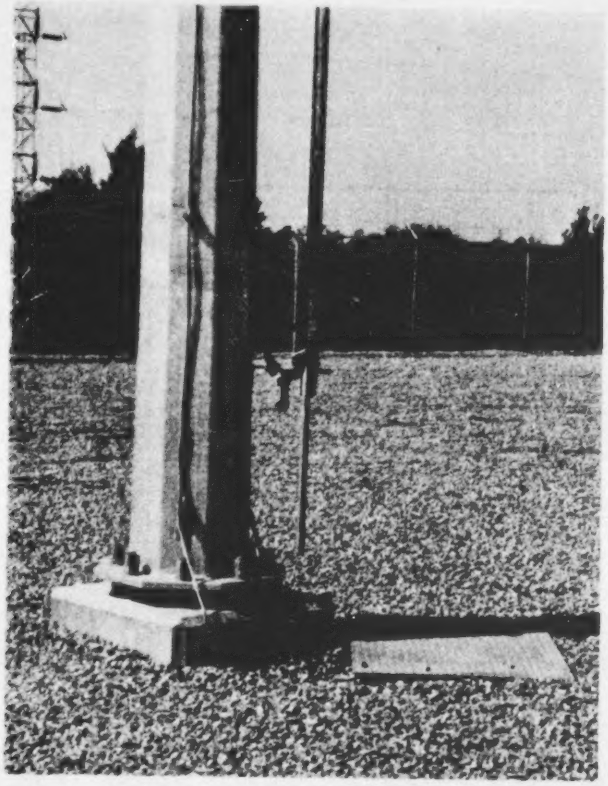
   D. Transformer-regulator



(NOTE: This transformer is a combination power transformer and voltage regulator. The voltage regulator may be a separate unit in some substations. Voltage regulations may be accomplished with one three-phase unit or three single-phase units.)

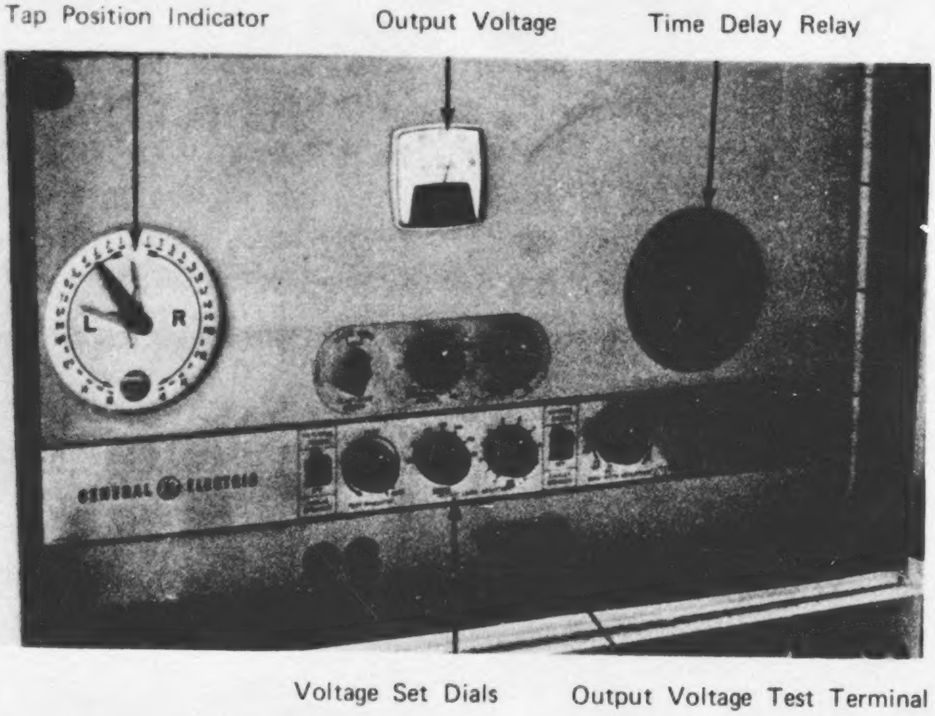
INFORMATION SHEET

E. Air-break switch operating handle



INFORMATION SHEET

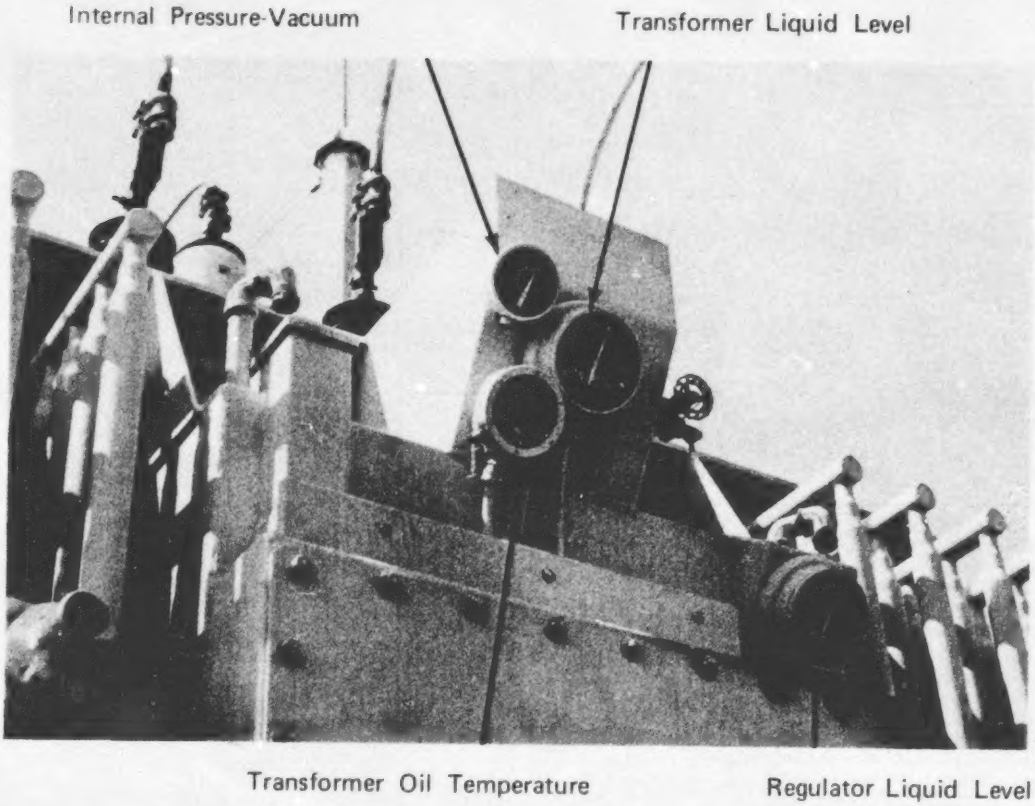
F. Voltage regulator panel



(NOTE: A built-in transformer in the regulator supplies potential for the output voltage meter and power for the tap changer drive unit.)

INFORMATION SHEET

G. Transformer-regulator indicator gauges

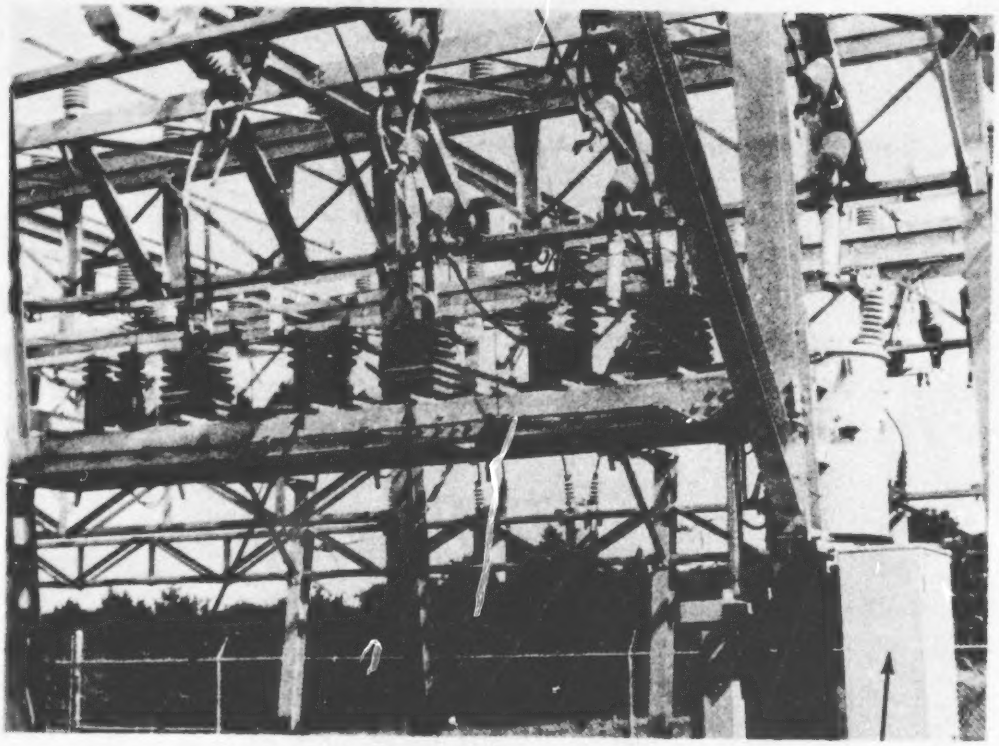


INFORMATION SHEET

H. Potential transformers

I. Current transformers

J. Metering cabinet



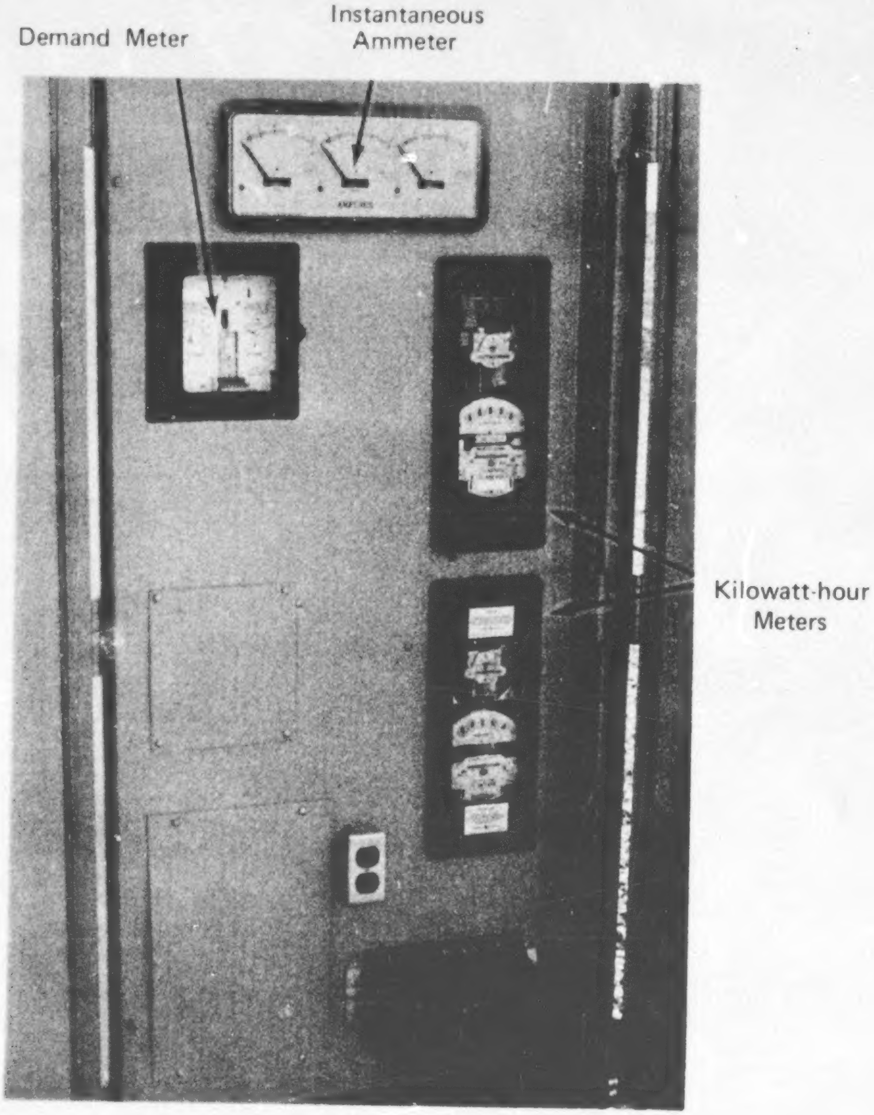
Potential Transformer Current Transformer Metering Cabinet

INFORMATION SHEET

K. Instantaneous ammeters

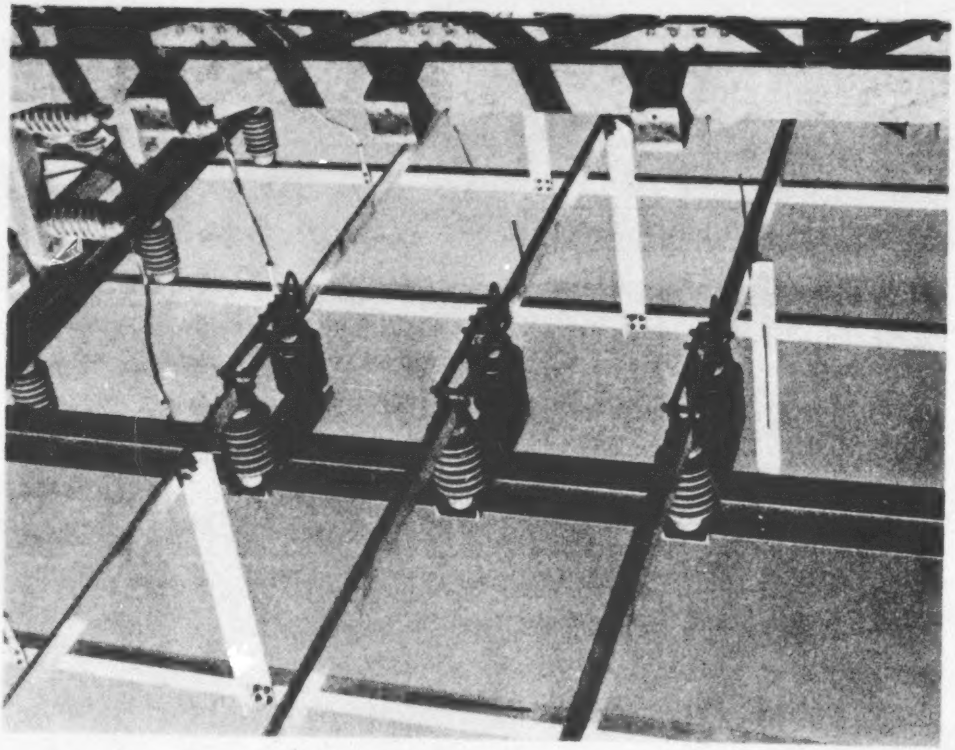
L. Demand meter with timed and printed tape

M. Kilowatt-hour meters



INFORMATION SHEET

N. Bus bars with disconnect switches



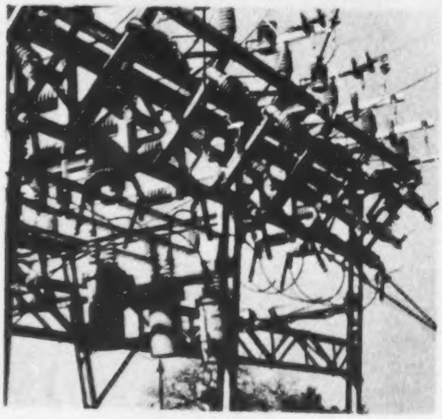
INFORMATION SHEET

O. Lightning arresters

P. Bypass switches (with bypass fuses removed)

Q. Disconnect switches

R. Oil circuit reclosers



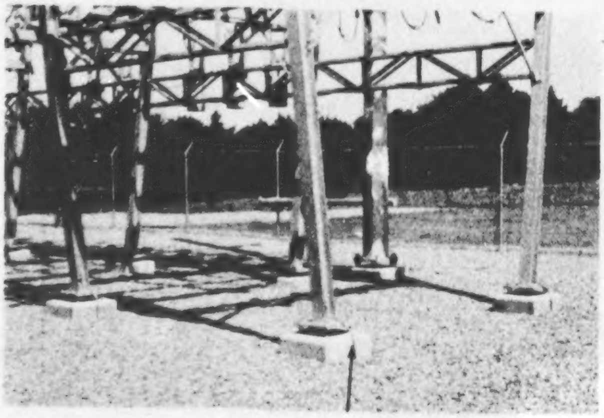
Bypass Switch

Lightning Arrester

Disconnect Switches

Oil Circuit Recloser

S. Substation ground



Ground

(NOTE: Each leg of the substation and each section of fence are solidly grounded to the ground grid under and around the substation.)

INFORMATION SHEET

III. Substation components and their uses

  A. Transmission line--Supplies power to substation

  B. Air-break switch--Serves as disconnect point between transmission line and substation

  C. Lightning arrester--Protects the substation from high voltage surges

  D. Transformer-regulator--Transforms transmission voltage to distribution voltage and maintains a constant outgoing voltage

  E. Air-break switch operating handle--Opens and closes air-break switch

  F. Voltage regulator panel--Indicates tap position, voltage, time delay relay position, and resistance and reactance compensation settings

  G. Transformer-regulator indicator gauge--Indicates temperature and level of oil

  H. Potential transformer--Supplies potential to kilowatt-hour meter

  I. Current transformer--Supplies proportionate amount of line current to meter

  J. Metering cabinet--Houses meters

  K. Instantaneous ammeter--Shows amperage on each phase

  L. Demand meter--Shows the highest amount of current required and the time it was required

  M. Kilowatt-hour meter--Shows the kilowatt hours registered

  N. Bus bar--Distributes power to each bay of the substation

  O. Substation bay--Houses three lightning arresters, three bypass switches, and three oil circuit reclosers

  P. Substation ground--Connects substation and substation fence to grounding grid

IV. Functions of a substation

  A. Provide a distribution point as close as possible to a load center

  B. Provide a metering point for distribution power

  C. Provide protection for the power transformer and the transmission line

INFORMATION SHEET

- D. Transform transmission voltage to distribution voltage
- E. Regulate voltage

V. Steps to take a substation out of service

- A. Notify your dispatcher
- B. Notify power supplier
- C. Open outgoing oil circuit reclosers and disconnect jumpers
- D. Open air-break switch
- E. Check air-break switch visually to see that it is open
- F. Lock air-break switch in open position

  (NOTE: Substation sites are sometimes used for a switching station for transmission lines.)

VI. Precautions to observe with a substation

- A. Do not go into a substation alone
- B. Do not store materials in a substation
- C. Do not close bypass switches except on oil circuit reclosers
- D. Do not open high side fuses under load
- E. Do not open air-break switch under load
- F. Keep substation gates locked except when working inside

VII. Procedure to change a substation oil circuit recloser

(NOTE: Notify the dispatcher before any work is performed.)

- A. Determine voltage, type, and size of recloser to be changed
- B. Select replacement recloser and place at job site
- C. Barricade rest of substation to keep workers in specified work area
- D. Close recloser bypass switch with insulated stick
- E. Open recloser by pulling down on operating handle with insulated stick
- F. Disconnect recloser jumpers and clear with insulated stick

INFORMATION SHEET

G. *Cover exposed live conductors on either side of recloser with rubber blankets* or line hose

H. Loosen securing bolts and remove recloser

I. Transfer line jumpers from old recloser to the new one

J. Install new recloser and secure mounting brackets to substation frame

K. Open the newly installed recloser by pulling down on operating handle

L. Connect recloser jumpers to load and source

M. Close newly installed recloser by pushing up on operating handle with insulated stick

N. Open bypass switch with insulated stick

O. Remove cover-up material and barricades

(NOTE: All work in a substation will be done in close proximity to energized parts unless the station is taken out of service. Always wear your personal protective equipment. Always ground and place hold cards on the de-energized circuits.)

VIII. Procedure to bypass a substation current transformer

A. Take the substation out of service

B. Ground the circuit

C. Remove jumpers from current transformer

D. Remove current transformer

E. Connect current transformer jumpers together

(NOTE: Do not cut the jumpers. They will be used to connect the new current transformer.)

F. Put substation back in service

(NOTE: Bypassing a current transformer is an emergency procedure to get a substation back in service. Some newer substations may have bypass switches for the current transformers.)

INFORMATION SHEET

IX. Indications in a substation that could cause an outage

  A. Arcing sound

  B. Bird's nest in the structure

  (NOTE: Snakes frequently cause outages in a substation while trying to reach a bird's nest.)

  C. Excessive heat in the power transformer

  (NOTE: A heat-indicating gauge on the power transformer has two pointers. One pointer indicates the internal temperature; the other pointer indicates the maximum temperature that the transformer has reached.)

  D. Excessive noise in transformer, regulator, or metering equipment

X. Indications and possible problems

  A. Arcing sound

    1. Burning connection

    2. Insulator breakdown

    3. Switch not properly closed

  B. Excessive heat in transformer

    1. Transformer overloaded

    2. Insulation breakdown in windings

    3. Cooling fans inoperative

  C. Broken porcelain or glass

    1. Insulator broken

    2. Lightning arrester blown

  D. Oil on ground or structure

    1. Leaking gasket on transformer or recloser

    2. Broken bushing on transformer or recloser

    3. Hole shot in transformer or recloser

SUBSTATIONS
UNIT II

TEST

NAME ______________________________ SCORE ________________

1. Match the terms on the right to the correct definitions.

_____a. Fuse which protects the transmission line from a short circuit in a substation

_____b. Buried metal mat or conductor under and around a substation

_____c. Lightning arrester designed to protect a substation transformer from high voltage surges

_____d. Switch designed to open a circuit which is not under heavy load

_____e. Switch designed to change current flow around a piece of equipment

_____f. Heavy conductor made of copper or aluminum wire or bar which distributes current in a substation

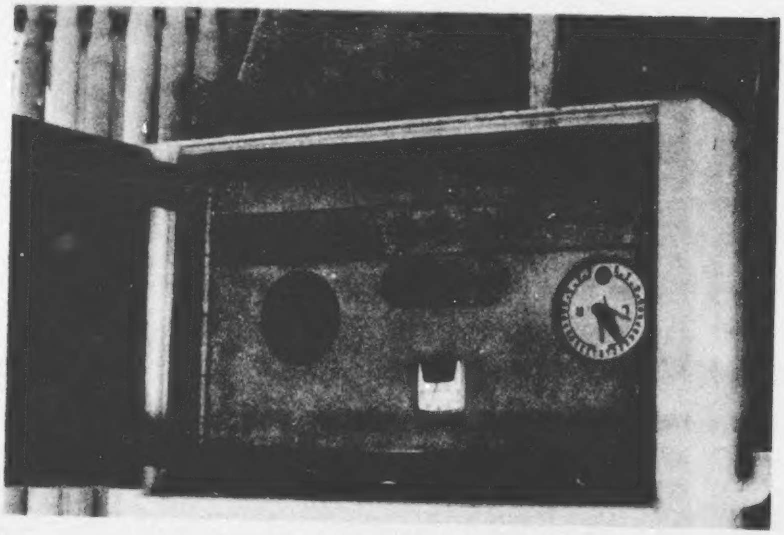
_____g. Section of a substation which contains one secondary three-phase circuit

_____h. Switch which protects the substation transformer from short circuits on distribution lines

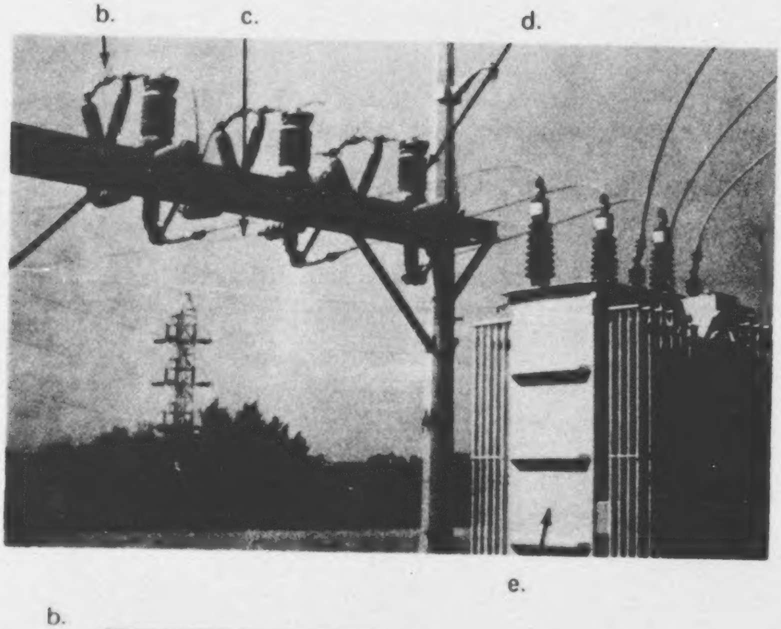
_____i. Switch used on heavy loads, usually above 200 amperes

1. Station arrester
2. Air-break switch
3. Bus
4. High side fuse
5. Grounding grid
6. Bypass switch
7. Oil circuit recloser
8. Bay
9. Vacuum recloser

2. Identify the following components of a substation.



a. ____________________

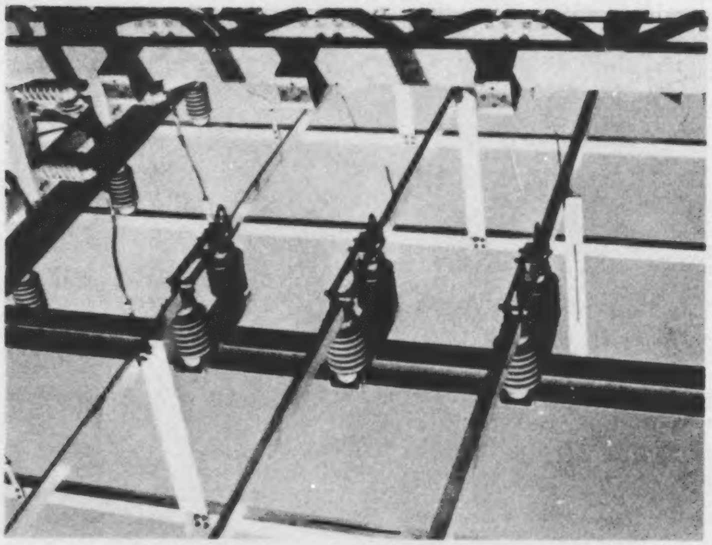


b. ____________________

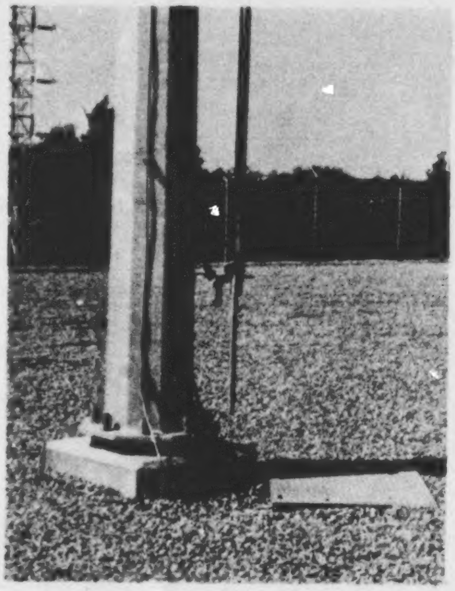
c. ____________________

d. ____________________

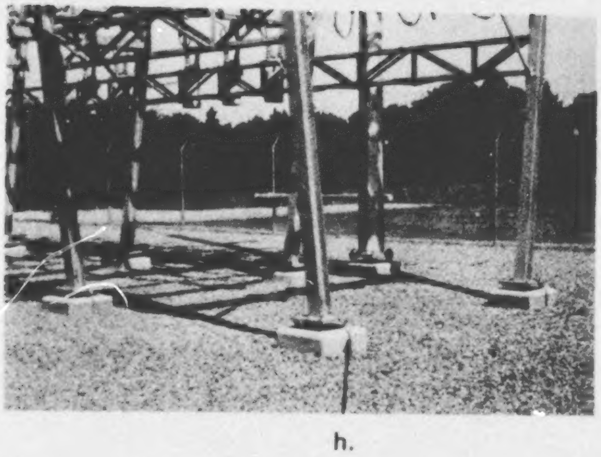
e. ____________________



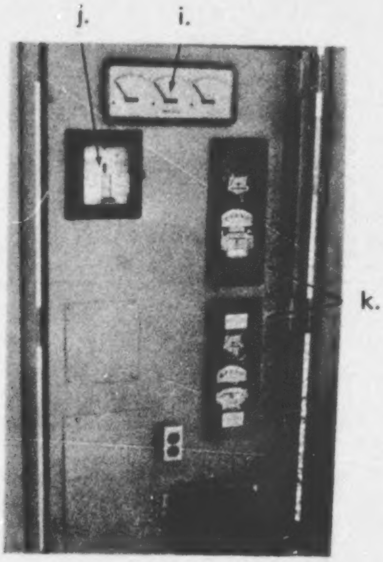
f. ____________________



g. ____________________



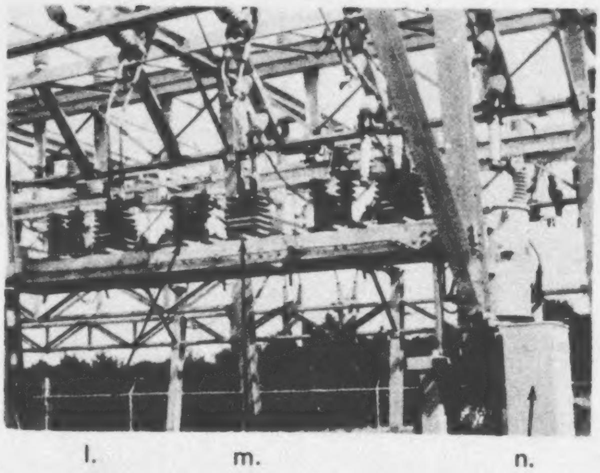
h. ____________________



i. ____________________

j. ____________________

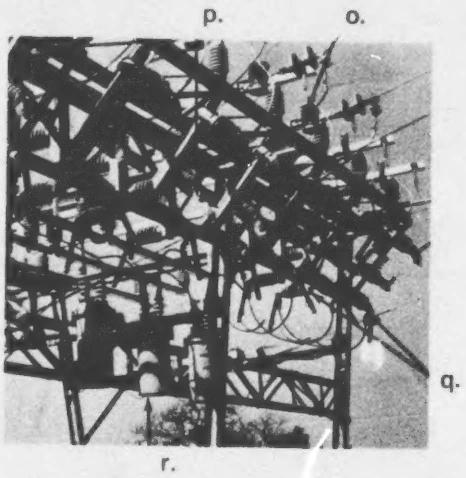
k. ____________________



l. ____________________

m. ____________________

n. ____________________

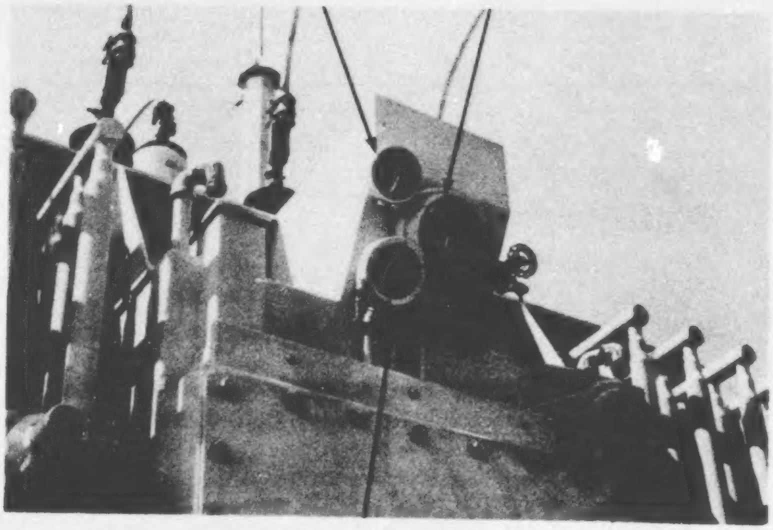


o. ____________________

p. ____________________

q. ____________________

r. ____________________



s. ____________________

3. Match the substation components on the right to the specific use.

_____a. Supplies power to substation

_____b. Serves as disconnect point between transmission line and substation

_____c. Protects the substation from high voltage surges

_____d. Transforms transmission voltage to distribution voltage and maintains a constant outgoing voltage

_____e. Opens and closes air-break switch

_____f. Indicates tap position, voltage, time delay relay position, and resistance and reactance compensation settings

_____g. Indicates temperature and level of oil

_____h. Supplies potential to kilowatt-hour meter

_____i. Supplies proportionate amount of line current to meter

_____j. Houses meters

_____k. Shows amperage on each phase

_____l. Shows the highest amount of current required and the time it was required

_____m. Shows the kilowatt-hours registered

_____n. Distributes power to each bay of the substation

_____o. Houses three lightning arresters, three bypass switches, and three oil circuit reclosers

_____p. Connects substation and substation fence to grounding grid

1. Bus bar
2. Lightning arrester
3. Voltage regulator panel
4. Transmission line
5. Substation ground
6. Instantaneous ammeter
7. Air-break switch
8. Transformer-regulator
9. Transformer-regulator indicator gauge
10. Substation bay
11. Metering cabinet
12. Air-break switch operating handle
13. Demand meter
14. Potential transformer
15. Current transformer
16. Kilowatt-hour meter

4. State four functions of a substation.

a. ____________________

____

b. ____________________

____

c. ____________________

____

d. ____________________

____

5. Arrange in proper order the following steps to take a substation out of service.

_____a. Open air-break switch

_____b. Notify your dispatcher

_____c. Lock air-break switch in open position

_____d. Notify power supplier

_____e. Open outgoing oil circuit reclosers and disconnect jumpers

_____f. Check air-break switch visually to see that it is open

6. Select from the following list the precautions to observe with a substation.

_____a. Do all work in a substation alone

_____b. Do not store materials in a substation

_____c. Keep substation gates locked except when working inside

_____d. Do not open high side fuses under load

_____e. Do not go into a substation alone

_____f. Open air-break switch under load

_____g. Do not close bypass switches except on oil circuit reclosers

_____h. Do not open air-break switch under load

7. Arrange in order the following procedure for changing a substation oil circuit recloser.

______a. Remove cover-up material and barricades

______b. Disconnect recloser jumpers and clear with insulated stick

______c. Transfer line jumpers from old recloser to the new one

______d. Select replacement recloser and place at job site

______e. Barricade rest of substation to keep workers in specified work area

______f. Connect recloser jumpers to load and source

______g. Loosen securing bolts and remove recloser

______h. Open the newly installed recloser by pulling down on operating handle

______i. Close recloser bypass switch with insulated stick

______j. Install new recloser and secure mounting brackets to substation frame

______k. Open bypass switch with insulated stick

______l. Open recloser by pulling down on operating handle with insulated stick

______m. Cover exposed live conductors on either side of recloser with rubber blankets or line hose

______n. Close newly installed recloser by pushing up on operating handle with insulated stick

______o. Determine voltage, type, and size of recloser to be changed

8. State the correct procedure for bypassing a substation current transformer.

a. ____

b. ____

c. ____

d. ____

e. ____

f. ____

9. List three indications in a substation that could cause an outage.

a. ______________________________

b. ______________________________

c. ______________________________

10. Match the indications on the right to the possible problems.

_____a. Burning connection; insulator breakdown; switch not properly closed

_____b. Transformer overloaded; insulation breakdown in windings; cooling fans inoperative

_____c. Insulator broken; lightning arrester blown

_____d. Leaking gasket on transformer or recloser; broken bushing on transformer or recloser; hole shot in transformer or recloser

1. Broken porcelain or glass

2. Oil on ground or structure

3. Excessive heat in transformer

4. Arcing sound

SUBSTATIONS
UNIT II

ANSWERS TO TEST

1. Match the terms on the right to the correct definitions.

 4 a. Fuse which protects the transmission line from a short circuit in a substation

 5 b. Buried metal mat or conductor under and around a substation

 1 c. Lightning arrester designed to protect a substation transformer from high voltage surges

 2 d. Switch designed to open a circuit which is not under heavy load

 6 e. Switch designed to change current flow around a piece of equipment

 3 f. Heavy conductor made of copper or aluminum wire or bar which distributes current in a substation

 8 g. Section of a substation which contains one secondary three-phase circuit

 7 h. Switch which protects the substation transformer from short circuits on distribution lines

 9 i. Switch used for heavy loads, usually above 200 amperes

1. Station arrester
2. Air-break switch
3. Bus
4. High side fuse
5. Grounding grid
6. Bypass switch
7. Oil circuit recloser
8. Bay
9. Vacuum recloser

2. Identify the following components of a substation.

a. Voltage regulator panel

b. Air-break switch (three-phase)

c. Transmission line

d. Lightning arrester (station type)

e. Transformer-regulator

f. Bus bars with disconnect switches

g. Air-break switch operating handle

h. Substation ground

i. Instantaneous ammeter

j. Demand meter with timed and printed tape

k. Kilowatt-hour meters

l. Potential transformer

m. Current transformer

n. Metering cabinet

o. Lightning arrester

p. Bypass switch

q. Disconnect switches

r. Oil circuit recloser

s. Transformer-regulator indicator gauges

3. Match the substation components on the right to the specific use.

__4__ a. Supplies power to substation

__7__ b. Serves as disconnect point between transmission line and substation

__2__ c. Protects the substation from high voltage surges

__8__ d. Transforms transmission voltage to distribution voltage and maintains a constant outgoing voltage

__12__ e. Opens and closes air-break switch

__3__ f. Indicates tap position, voltage, time delay relay position, and resistance and reactance compensation settings

__9__ g. Indicates temperature and level of oil

__14__ h. Supplies potential to kilowatt-hour meter

__15__ i. Supplies proportionate amount of line current to meter

__11__ j. Houses meters

__6__ k. Shows amperage on each phase

1. Bus bar
2. Lightning arrester
3. Voltage regulator panel
4. Transmission line
5. Substation ground
6. Instantaneous ammeter
7. Air-break switch
8. Transformer-regulator
9. Transformer-regulator indicator gauge
10. Substation bay
11. Metering cabinet
12. Air-break switch operating handle

13 l. Shows the highest amount of current required and the time it was required

16 m. Shows the kilowatt-hours registered

1 n. Distributes power to each bay of the substation

10 o. Houses three lightning arresters, three bypass switches, and three oil circuit reclosers

5 p. Connects substation and substation fence to grounding grid

13. Demand meter
14. Potential transformer
15. Current transformer
16. Kilowatt-hour meter

4. State four functions of a substation.

(NOTE: Any four of the following are acceptable.)

a. Provide a distribution point as close as possible to a load center

b. Provide a metering point for distribution power

c. Provide protection for the power transformer and the transmission line

d. Transform transmission voltage to distribution voltage

e. Regulate voltage

5. Arrange in proper order the following steps to take a substation out of service.

4 a. Open air-break switch

1 b. Notify your dispatcher

6 c. Lock air-break switch in open position

2 d. Notify power supplier

3 e. Open outgoing oil circuit reclosers and disconnect jumpers

5 f. Check air-break switch visually to see that it is open

6. Select from the following list the precautions to observe with a substation.

____ a. Do all work in a substation alone

X b. Do not store materials in a substation

X c. Keep substation gates locked except when working inside

X d. Do not open high side fuses under load

__X__ e. Do not go into a substation alone

______ f. Open air-break switch under load

__X__ g. Do not close bypass switches except on oil circuit reclosers

__X__ h. Do not open air-break switch under load

7. Arrange in order the following procedure for changing a substation oil circuit recloser.

__15__ a. Remove cover-up material and barricades

__6__ b. Disconnect recloser jumpers and clear with insulated stick

__9__ c. Transfer line jumpers from old recloser to the new one

__2__ d. Select replacement recloser and place at job site

__3__ e. Barricade rest of substation to keep workers in specified work area

__12__ f. Connect recloser jumpers to load and source

__8__ g. Loosen securing bolts and remove recloser

__11__ h. Open the newly installed recloser by pulling down on operating handle

__4__ i. Close recloser bypass switch with insulated stick

__10__ j. Install new recloser and secure mounting brackets to substation frame

__14__ k. Open bypass switch with insulated stick

__5__ l. Open recloser by pulling down on operating handle with insulated stick

__7__ m. Cover exposed live conductors on either side of recloser with rubber blankets or line hose

__13__ n. Close newly installed recloser by pushing up on operating handle with insulated stick

__1__ o. Determine voltage, type, and size of recloser to be changed

8. State the correct procedure for bypassing a substation current transformer.

a. Take the substation out of service

b. Ground the circuit

c. Remove jumpers from current transformer

d. Remove current transformer

e. Connect current transformer jumpers together

f. Put substation back in service

9. List three indications in a substation that could cause an outage.

(NOTE: Any three of the following answers are acceptable.)

a. Arcing sound

b. Bird's nest in the structure

c. Excessive heat in the power transformer

d. Excessive noise in transformer, regulator, or metering equipment

10. Match the indications on the right to the possible problems.

__4__ a. Burning connection; insulator breakdown; switch not properly closed

__3__ b. Transformer overloaded; insulation breakdown in windings; cooling fans inoperative

__1__ c. Insulator broken; lightning arrester blown

__2__ d. Leaking gasket on transformer or recloser; broken bushing on transformer or recloser; hole shot in transformer or recloser

1. Broken porcelain or glass
2. Oil on ground or structure
3. Excessive heat in transformer
4. Arcing sound

GROUNDS AND JUMPERS
(LINE EQUIPMENT)
UNIT III

UNIT OBJECTIVE

After completion of this unit, the student should be able to select and install jumpers. The student should be able to safely ground line equipment and determine proper and improper grounding methods. This knowledge will be evidenced by scoring 85 percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms commonly used with grounds and jumpers to the correct definitions.
2. List types of jumpers.
3. Match various types of jumpers to the specific use.
4. State requirements for various jumpers.
5. Select from a list the line equipment that is connected by jumpers.
6. Match types of jumpers to the correct installation methods.
7. State the requirements for safe grounding of line equipment.
8. Identify grounding methods.
9. Calculate current flow of faulted equipment which is improperly grounded.
10. Calculate voltage on improperly grounded faulted equipment.

GROUNDS AND JUMPERS
(LINE EQUIPMENT)
UNIT III

SUGGESTED ACTIVITIES

I. Suggested activities for instructor:

   A. Provide student with objective sheet.

   B. Provide student with information and assignment sheets.

   C. Make transparencies.

   D. Discuss unit and specific objectives.

   E. Discuss information and assignment sheets.

   F. Give test.

II. Unit references:

   A. Rural Electrification Administration. *Grounding.* Bulletin 83-1. Washington, D.C.: U.S. Department of Agriculture, 1966.

   B. Kurtz, Edwin B., and Shoemaker, Thomas M. *The Lineman's and Cableman's Handbook.* 5th ed. New York: McGraw-Hill Book Co., 1976.

GROUNDS AND JUMPERS
(LINE EQUIPMENT)
UNIT III

INFORMATION SHEET

I. Terms and definitions

   A. Jumper--Short piece of wire used to close an opening [illegible]

   B. Terminal--Attachment on line equipment used to connect [illegible] conductor

   C. Plating--Coating on terminal or connector to make it suitable for copper or aluminum conductors

   D. Bi-metal--Two different metals fused together

   E. Cold-flow--Movement of soft metal caused by expansion and contraction or pressure on a small area

   F. Electrolytic corrosion--Destruction of aluminum conductor when moisture is present at the junction of two different kinds of metal

II. Types of jumpers (Transparency 1)

   A. Line

   B. Insulated

   C. Grounding

III. Uses of jumpers

   A. Line jumper

      1. Connects line conductor at corners and double dead-ends

      2. Connects line equipment to line conductor

   B. Insulated jumper--Connects opening in line conductor while changes or repairs are being made

   C. Grounding jumper

      1. Connects line neutral at corners and double dead ends

      2. Connects line equipment to neutral and pole ground

INFORMATION SHEET

IV. Requirements for jumpers

- A. Line jumper
  - 1. Must consist of similar material as the conductor being connected
  - 2. Must be the same size or ampacity as the conductor being connected
- B. Insulated jumper--Must have insulation value greater than the voltage on which it is used
- C. Grounding jumper
  - 1. Must be large enough to carry unwanted currents
  - 2. Must be bonded solidly to the conductor or equipment being grounded

V. Line equipment connected by jumpers

- A. Transformer
- B. Fuse cut-out
- C. Lightning arrester
- D. Capacitor
- E. Voltage regulator
- F. Oil circuit recloser
- G. Sectionalizer
- H. Line switch

VI. Methods to install jumpers (Transparency 2)

- A. Copper jumpers
  - 1. Install with copper or compression connector
  - 2. Install with slack to avoid vibration damage
  - 3. Install with bronze or plated connector
  - 4. Install with bi-metal or plated connector

INFORMATION SHEET

B. Aluminum jumpers

1. Install with large area or compression connector
2. Install with bi-metal or plated connector
3. Install with coating of inhibitor
4. Install with slack to avoid vibration damage
5. Install with copper ends when connecting to bronze or unplated terminals
6. Install with aluminum connector

(NOTE: Cold-flow occurs when aluminum conductor is installed with small area or set screw connectors. The problems of poor connections caused by cold-flow can be greatly reduced if large area or compression connectors are used with aluminum jumpers.)

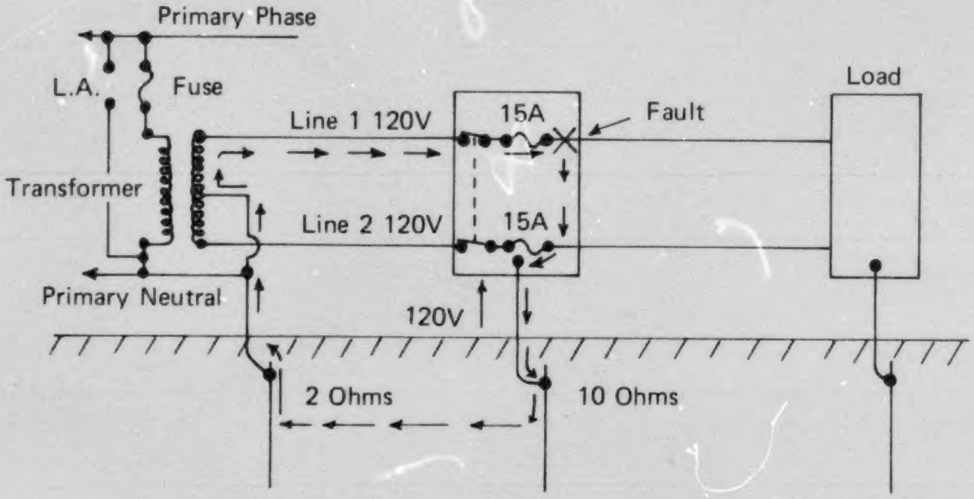
VII. Requirements for safe grounding of line equipment

A. All metal parts which are not used as energized conductors shall be grounded

B. All grounded parts shall be interconnected with a metallic conductor extending to the source

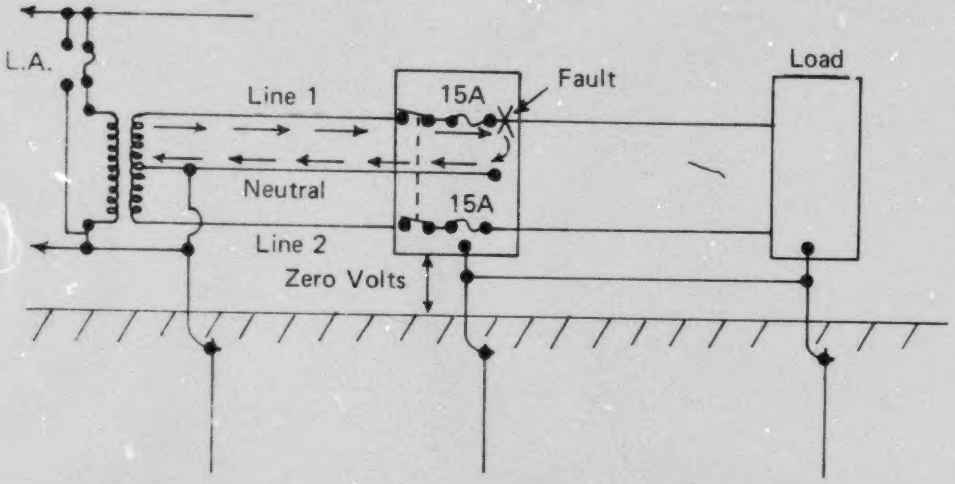
VIII. Grounding methods

A. Improper secondary grounding

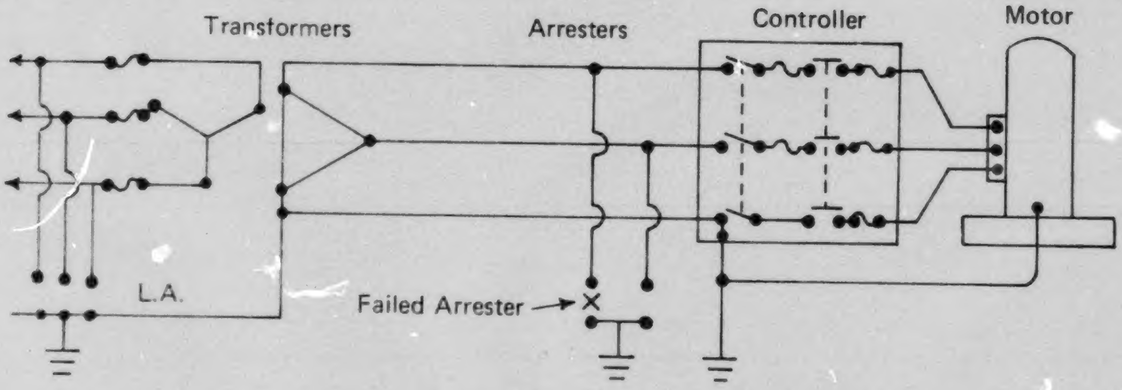


INFORMATION SHEET

B. Proper secondary grounding



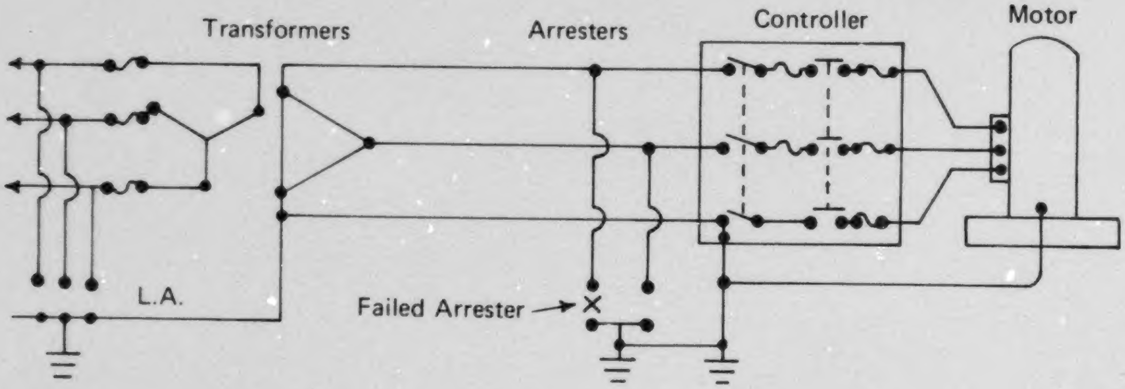
C. Improper secondary arrester grounding



(NOTE: Failure of an arrester connected to an isolated ground can put lethal voltage on the arrester grounding conductor.)

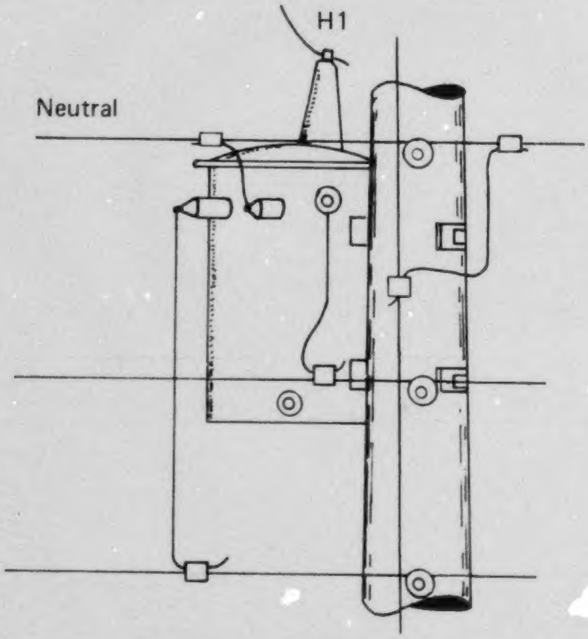
INFORMATION SHEET

D. Proper secondary arrester grounding



(NOTE: With interconnected grounds the current flow will be high because the resistance is low. The high current flow will blow the transformer fuse.)

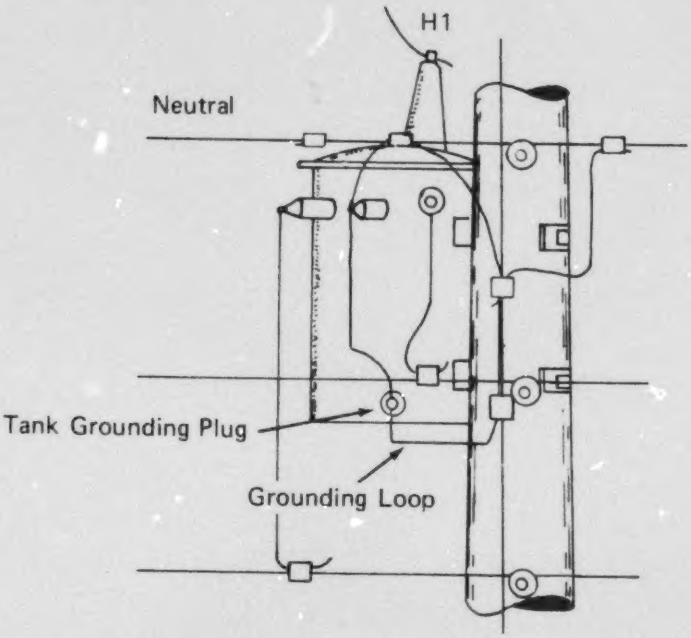
E. Improper transformer grounding



(NOTE: The primary winding in a single bushing transformer is connected to the transformer tank. If the tank is not grounded, primary voltage will exist on the transformer tank.)

INFORMATION SHEET

F. Proper transformer grounding



IX. Current flow of improperly grounded faulted equipment (Assignment Sheet #1)

Formula: Voltage ÷ Resistance = Amperes

Line voltage = 120 volts

Ground path resistance = 12 ohms

120 volts ÷ 12 ohms = 10 amperes (current flow)

(NOTE: Ten amperes flowing through a circuit that is fused at fifteen amperes will not blow the fuse. The current flow could continue indefinitely unless the load adds enough current to blow the fuse.)

X. Calculating voltage on improperly grounded faulted equipment (Assignment Sheet #2)

Formula: Amperes x Resistance = Voltage

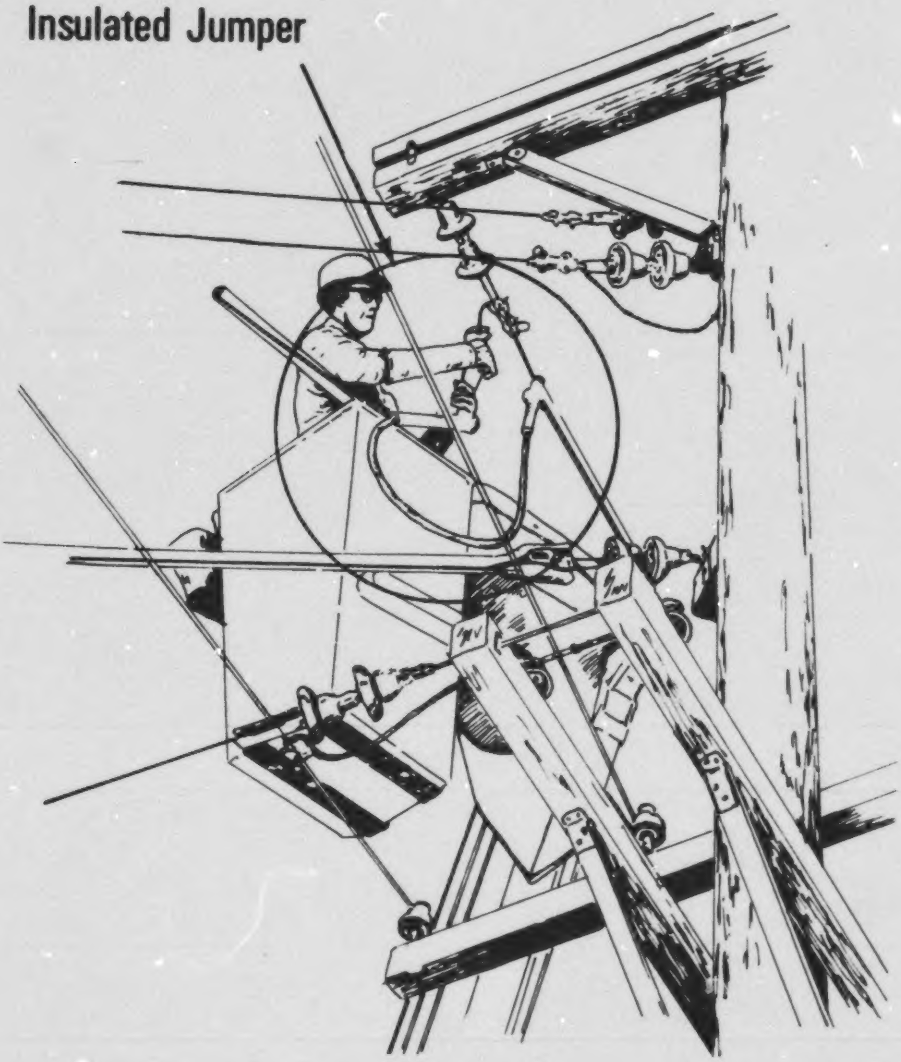
Current flow = 10 amperes

Ground path resistance = 12 ohms

10 amperes x 12 ohms = 120 volts

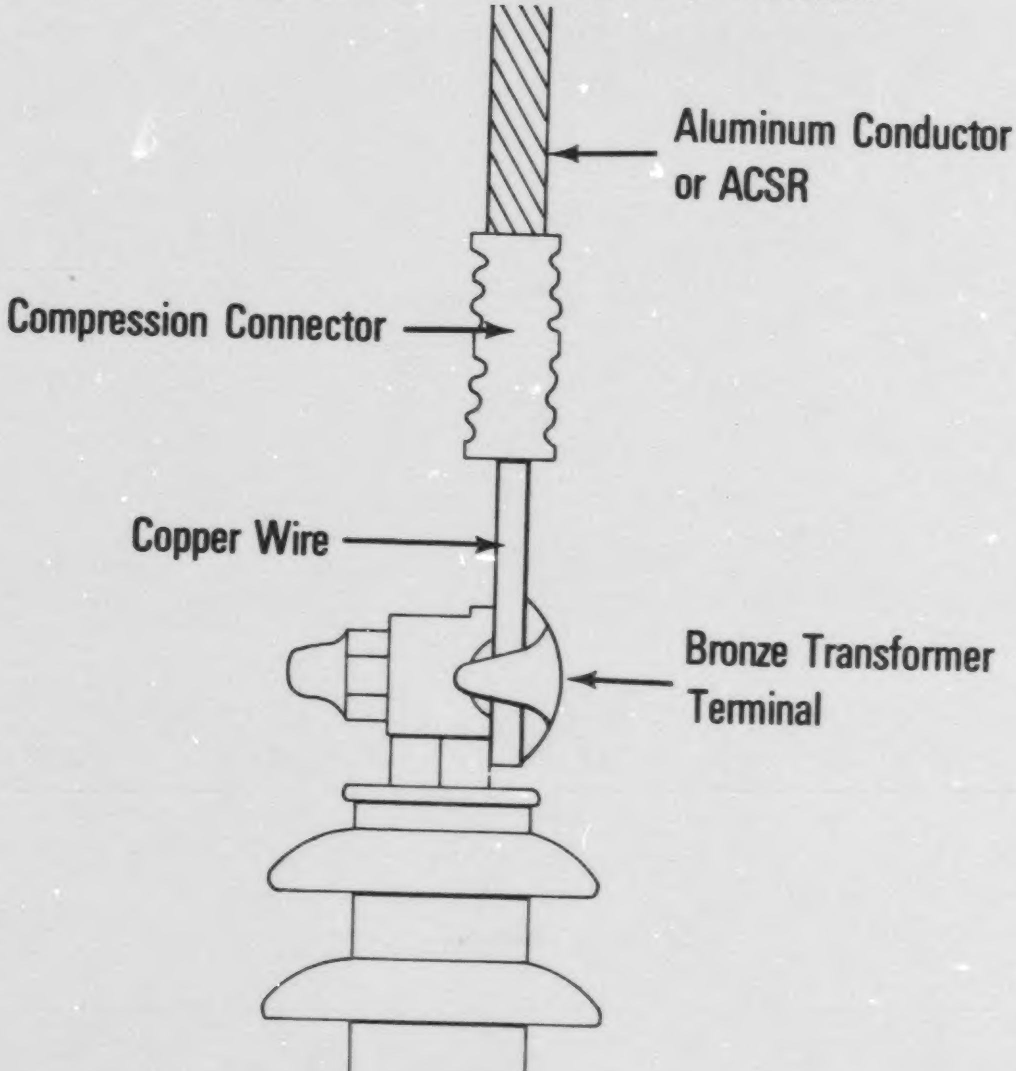
Voltage on equipment = 120 volts

Using Insulated Jumper



The line technician has installed an insulated jumper to keep the circuit closed while a bolt-on connector is being replaced with a crimp type connector.

Safe Connection of Aluminum Conductor to Unplated Bronze Terminal



GROUNDS AND JUMPERS
(LINE EQUIPMENT)
UNIT III

ASSIGNMENT SHEET #1--CALCULATE CURRENT FLOW THROUGH FAULTED EQUIPMENT

Calculate the current flow through faulted equipment when the voltage has been measured between the equipment and a solid ground and the resistance has been measured through the ground path of faulted equipment.

Current flow = Voltage ÷ Ohms

1. Line voltage = 120 volts
   Ground path resistance = 12 ohms
   Current flow = ___________

2. Line voltage = 240 volts
   Ground path resistance = 20 ohms
   Current flow = ___________

3. Line voltage = 7200 volts
   Resistance to ground = 10 ohms
   Current flow = ___________

4. Line voltage = 14,400 volts
   Resistance to ground = 80 ohms
   Current flow = ___________

GROUNDS AND JUMPERS
(LINE EQUIPMENT)
UNIT III

ASSIGNMENT SHEET #2--CALCULATE VOLTAGE ON FAULTED EQUIPMENT

Calculate the voltage on faulted equipment when current flow and ground path resistance have been measured.

Voltage = Amperes x Ohms

1. Current flow = 5 amperes
   Ground path resistance = 20 ohms
   Volts on equipment = ___________

2. Current flow = 20 amperes
   Ground path resistance = 10 ohms
   Volts on equipment = ___________

3. Current flow = 8 amperes
   Ground path resistance = 20 ohms
   Volts on equipment = ___________

4. Current flow = 12 amperes
   Ground path resistance = 40 ohms
   Volts on equipment = ___________

GROUNDS AND JUMPERS
(LINE EQUIPMENT)
UNIT III

ANSWERS TO ASSIGNMENT SHEETS

Assignment Sheet #1

1. 10 amperes
2. 12 amperes
3. 720 amperes
4. 180 amperes

Assignment Sheet #2

1. 100 volts
2. 200 volts
3. 160 volts
4. 480 volts

GROUNDS AND JUMPERS
(LINE EQUIPMENT)
UNIT III

TEST

NAME ______________________________ SCORE ____________________

1. Match the terms on the right to the correct definitions.

_____a. Movement of soft metal caused by expansion and contraction or pressure on a small area

_____b. Two different metals fused together

_____c. Destruction of aluminum conductor when moisture is present at the junction of two different kinds of metal

_____d. Attachment on line equipment used to connect a conductor

_____e. Short piece of wire used to close an opening in a circuit

_____f. Coating on terminal or connector to make it suitable for copper or aluminum conductors

1. Terminal
2. Cold-flow
3. Electrolytic corrosion
4. Bi-metal
5. Jumper
6. Plating

2. List three types of jumpers.

a. ____________________

b. ____________________

c. ____________________

3. Match the jumpers on the right to the correct uses.

_____a. Connects opening in line conductor while changes or repairs are being made

_____b. Connects line neutral at corners and double dead ends; connects line equipment to neutral and pole ground

_____c. Connects line conductor at corners and double dead ends; connects line equipment to line conductor

1. Line jumper
2. Insulated jumper
3. Grounding jumper

4. State one requirement for each of the following types of jumpers.

   a. Line jumper-- ____

   ____

   b. Insulated jumper-- ____

   ____

   c. Grounding jumper-- ____

   ____

5. Select from the following list the line equipment connected by jumpers by placing an "X" in the blanks.

   ______a. Line switch

   ______b. Voltage regulator

   ______c. Crossarm

   ______d. Capacitor

   ______e. Lightning arrester

   ______f. Transformer

   ______g. Oil circuit recloser

   ______h. Fuse cut-out

   ______i. Sectionalizer

6. Match the jumpers on the right to the correct methods of installation. (Some answers include both kinds of jumpers.)

   ______a. Install with copper ends when connecting to bronze or unplated terminals

   ______b. Install with aluminum connector

   ______c. Install with coating of inhibitor

   ______d. Install with bi-metal or plated connector

   ______e. Install with slack to avoid vibration damage

   ______f. Install with large area or compression connector

   ______g. Install with copper or compression connector

   1. Copper

   2. Aluminum

7. State two requirements for safe grounding of line equipment.

a. ______________________________

____

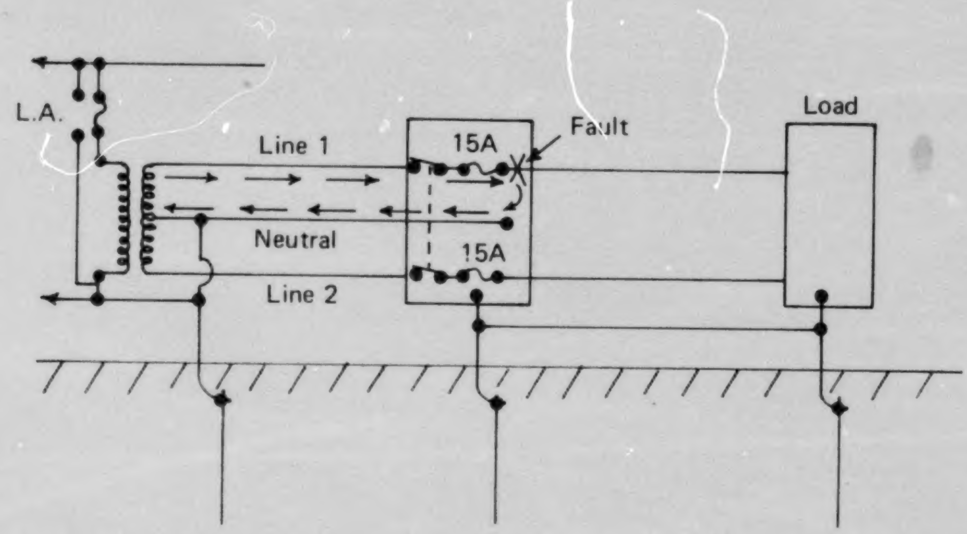
____

b. ______________________________

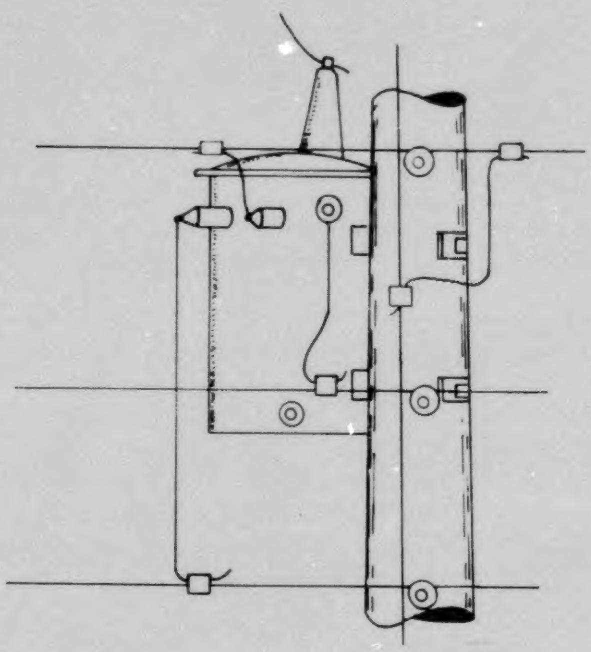
____

____

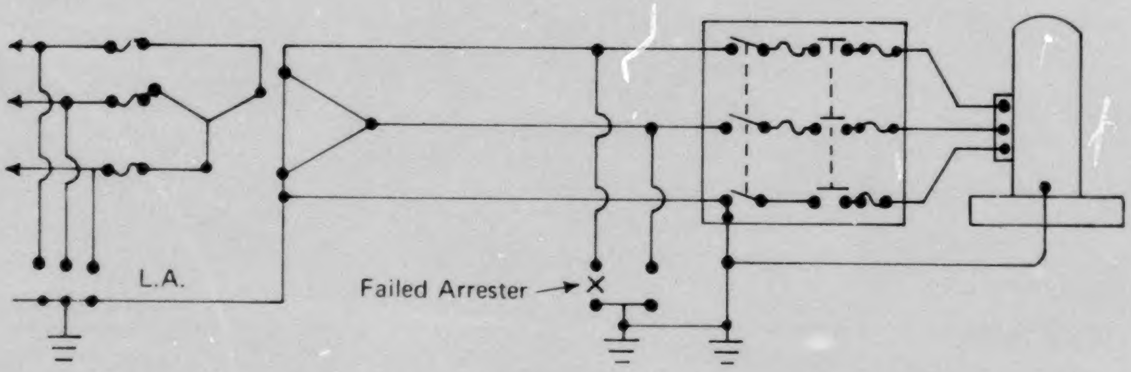
8. Identify the following grounding methods by placing a "P" in the blank by the equipment which is properly grounded and an "I" by the improperly grounded equipment.



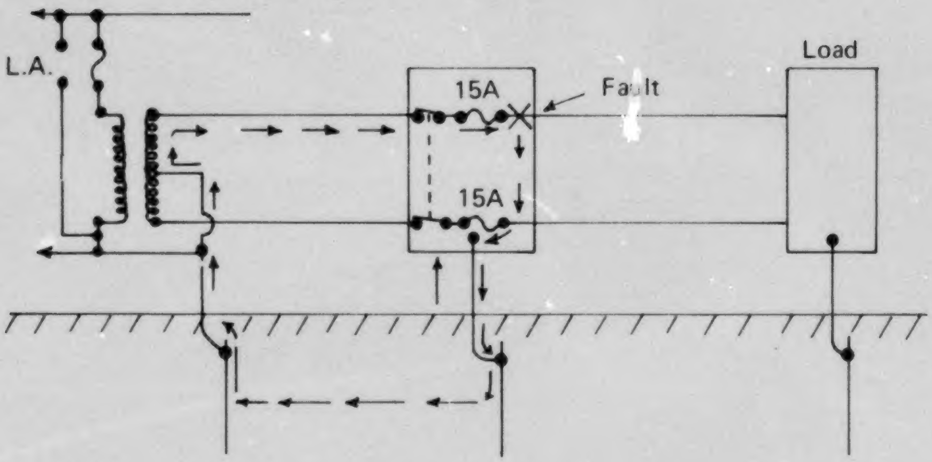
a. __________



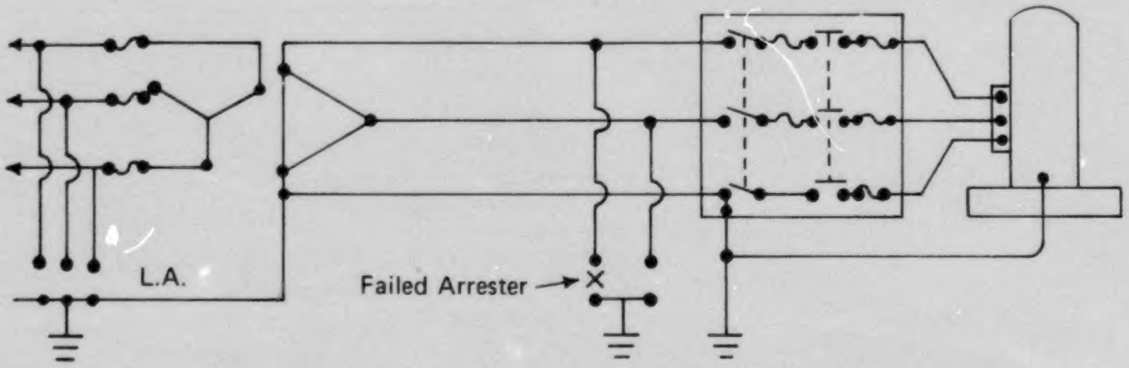
b. ____________



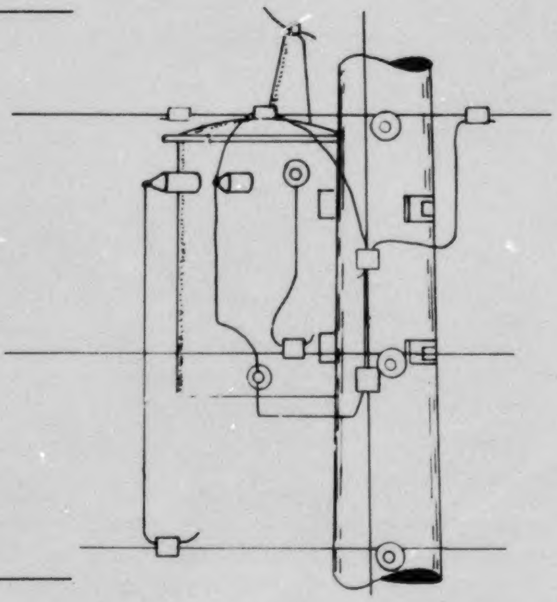
c. ____________



d. ______________



e. ______________



f. ______________

9. Calculate the current flow through improperly grounded faulted equipment.

Formula: Voltage ÷ Resistance = Amperes

Line voltage = 240 volts
Ground path resistance = 15 ohms
Current flow = ____________ amperes

10. Calculate the voltage on improperly grounded faulted equipment.

Formula: Amperes x Resistance = Voltage

Current flow = 5 amperes
Ground path resistance = 18 ohms
Voltage = ____________volts

GROUNDS AND JUMPERS
(LINE EQUIPMENT)
UNIT III

ANSWERS TO TEST

1. Match the terms on the right to the correct definitions.

2 a. Movement of soft metal caused by expansion and contraction or pressure on a small area
4 b. Two different metals fused together
3 c. Destruction of aluminum conductor when moisture is present at the junction of two different kinds of metal
1 d. Attachment on line equipment used to connect a conductor
5 e. Short piece of wire used to close an opening in a circuit
6 f. Coating on terminal or connector to make it suitable for copper or aluminum conductors

1. Terminal
2. Cold-flow
3. Electrolytic corrosion
4. Bi-metal
5. Jumper
6. Plating

2. List three types of jumpers.

a. Line
b. Insulated
c. Grounding

3. Match the jumpers on the right to the correct uses.

2 a. Connects opening in line conductor while changes or repairs are being made
3 b. Connects line neutral at corners and double dead ends; connects line equipment to neutral and pole ground
1 c. Connects line conductor at corners and double dead ends; connects line equipment to line conductor

1. Line jumper
2. Insulated jumper
3. Grounding jumper

4. State one requirement for each of the following types of jumpers.

   a. Line jumper

      1) Must consist of similar material as the conductor being connected

      2) Must be the same size or ampacity as the conductor being connected

   b. Insulated jumper--Must have insulation value greater than the voltage on which it is used

   c. Grounding jumper

      1) Must be large enough to carry unwanted currents

      2) Must be bonded solidly to the conductor or equipment being grounded

5. Select from the following list the line equipment connected by jumpers by placing an "X" in the blanks.

__X__ a. Line switch

__X__ b. Voltage regulator

_____ c. Crossarm

__X__ d. Capacitor

__X__ e. Lightning arrester

__X__ f. Transformer

__X__ g. Oil circuit recloser

__X__ h. Fuse cut-out

__X__ i. Sectionalizer

6. Match the jumpers on the right to the correct methods of installation. (Some answers include both kinds of jumpers.)

__2__ a. Install with copper ends when connecting to bronze or unplated terminals	1. Copper 2. Aluminum
__2__ b. Install with aluminum connector	
__2__ c. Install with coating of inhibitor	
__1,2__ d. Install with bi-metal or plated connector	

1,2 e. Install with slack to avoid vibration damage

2 f. Install with large area or compression connector

1 g. Install with copper or compression connector

7. State two requirements for safe grounding of line equipment.

   a. All metal parts which are not used as energized conductors shall be grounded

   b. All grounded parts shall be interconnected with a metallic conductor extending to the source

8. Identify the following grounding methods by placing a "P" in the blank by the equipment which is properly grounded and an "I" by the improperly grounded equipment.

   a. P

   b. I

   c. P

   d. I

   e. I

   f. P

9. Calculate the current flow through improperly grounded faulted equipment.

   Formula: Voltage ÷ Resistance = Amperes

   Line voltage = 240 volts
   Ground path resistance = 15 ohms
   Current flow = 16 amperes

10. Calculate the voltage on improperly grounded faulted equipment.

   Formula: Amperes x Resistance = Voltage

   Current flow = 5 amperes
   Ground path resistance = 18 ohms
   Voltage = 90 volts

VOLTAGE AND CURRENT MEASURING
UNIT IV

UNIT OBJECTIVE

After completion of this unit, the student should be able to state the purposes of voltage and current measurements and be able to match currents and voltages to KVA ratings on service and primary lines. This knowledge will be evidenced by scoring 85 percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms commonly used with voltage and current measurements to the correct definitions.
2. State the purposes of voltage and current measurements.
3. Identify various pieces of equipment used for voltage and current measurement.
4. State the correct procedure for determining voltage drop of a service.
5. State the correct procedure for determining current demand on a primary circuit in a specific area.
6. State procedures for determining current demand on a transformer.
7. List steps to obtain primary line voltage drop.
8. Select from a list reasons for current measurements.
9. Match full load currents to the KVA ratings of a transformer.
10. Select from a list precautions to observe when making voltage and current measurements.

VOLTAGE AND CURRENT MEASURING
UNIT IV

SUGGESTED ACTIVITIES

I. Suggested activities for instructor:

  A. Provide student with objective sheet.

  B. Provide student with information sheet.

  C. Discuss unit and specific objectives.

  D. Discuss information sheet.

  E. Display voltage and current measuring instruments.

  F. Give test.

II. Unit references:

  A. Rural Electrification Administration. *Guide for Making Voltage Measurements on Rural Distribution Systems.* REA Bulletin 161-7. Washington, D.C.: U.S. Department of Agriculture, 1955.

  B. Rural Electrification Administration. *Voltage and Current Investigations.* REA Bulletin 161-8. Washington, D.C.: U.S. Department of Agriculture, 1959.

  C. Rural Electrification Administration. *Application Guide for Transformers.* REA Bulletin 161-22. Washington, D.C.: U.S. Department of Agriculture, 1961.

VOLTAGE AND CURRENT MEASURING
UNIT IV

INFORMATION SHEET

I. Terms and definitions

  A. Indicating voltmeter--Voltmeter which gives instantaneous maximum and minimum readings

  B. Recording voltmeter--Voltmeter which records voltage and time readings on a tape or chart

  C. Shop standard--Meter used to calibrate instruments used for actual testing

  D. Voltage drop--Source output voltage minus the voltage at the end of the line

  E. Voltage spread--Limit that service voltage varies from recommended base

  F. Peak load--Time during a day when maximum line current is flowing

  G. Voltage levels--Minimum and maximum voltage from a 120-volt base

  H. Power factor meter--Meter which indicates whether the line current leads or lags the voltage in electrical degrees

  I. Ammeter--Meter which indicates current flow in amperes

II. Purposes of voltage and current measurements

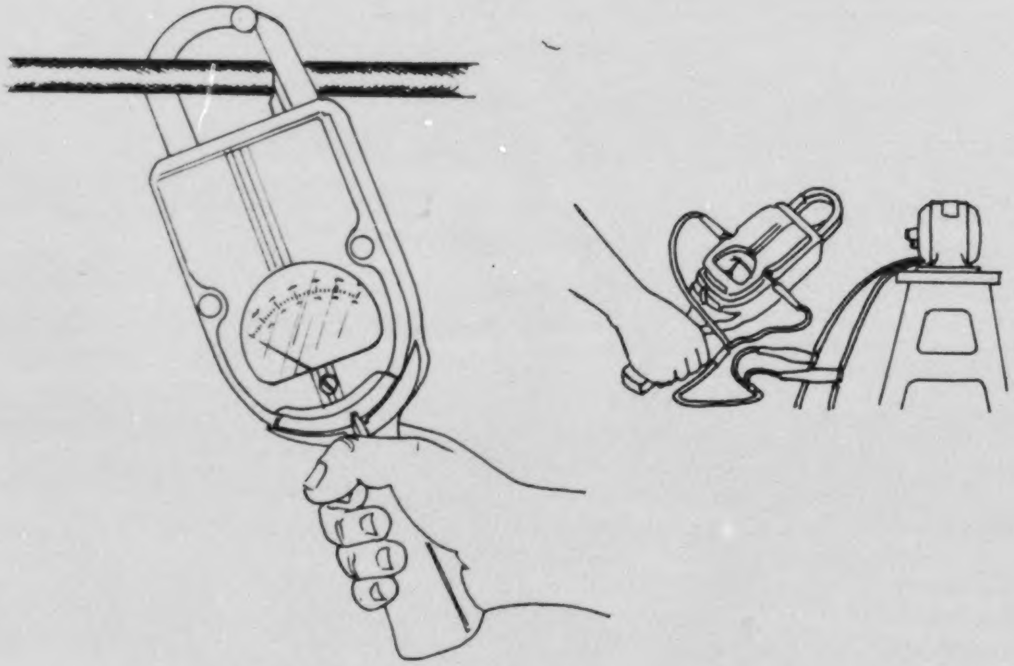
  A. Provide valuable information for the operation and development of an electrical system

  B. Provide basic data for maintaining adequate voltage levels and current balance

INFORMATION SHEET

III. Voltage and current measuring equipment

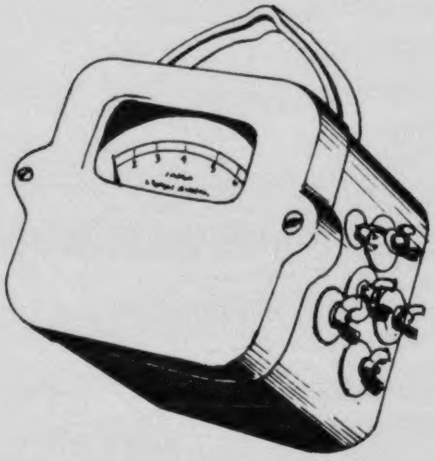
A. Clamp-on volt-ammeter



(NOTE: The clamp-on volt-ammeter may be used with an insulated stick attached to the handle to take ampere readings on primary voltage lines or to check amperes and voltage on low voltage circuits.)

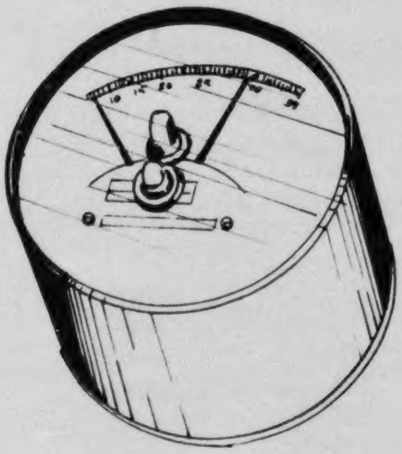
INFORMATION SHEET

B. Primary line ammeter



(NOTE: This type of ammeter gives an instantaneous reading and indicates what the maximum line current has been. This type of meter replaces a jumper. It clamps onto the conductor without other connections.)

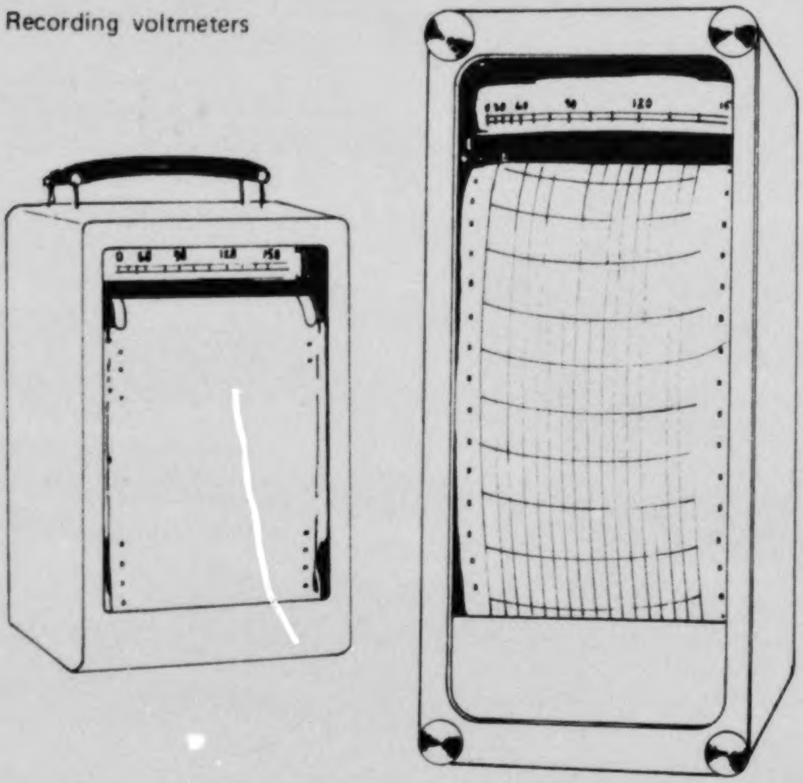
C. Socket type indicating ammeter



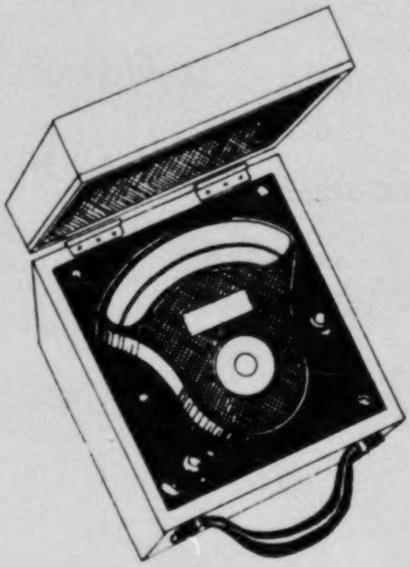
(NOTE: The socket type ammeter may be placed in series with a kilowatt-hour meter to obtain maximum current requirements.)

INFORMATION SHEET

D. Recording voltmeters

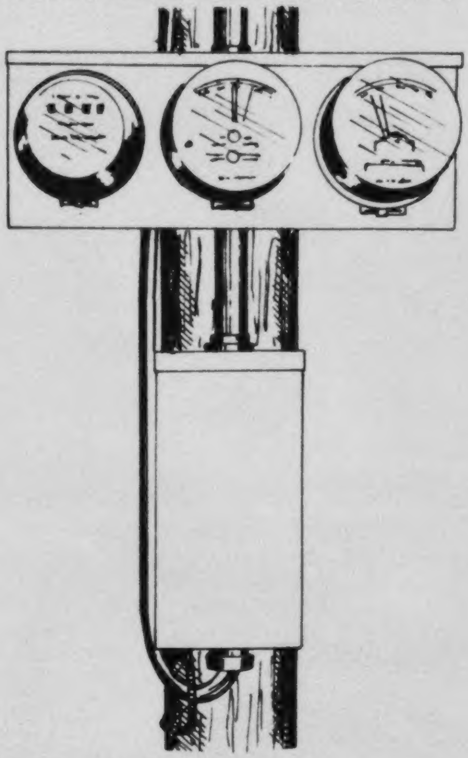


E. Shop standard voltmeter

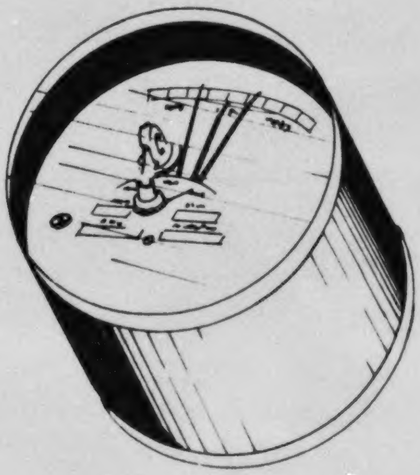


INFORMATION SHEET

F. Kilowatt-hour, volt, and ammeter test block

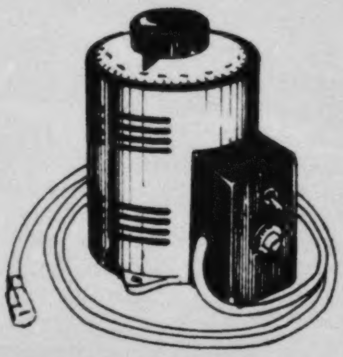


G. Socket type voltmeter



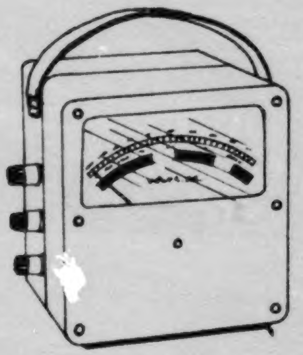
INFORMATION SHEET

H. Variable voltage source



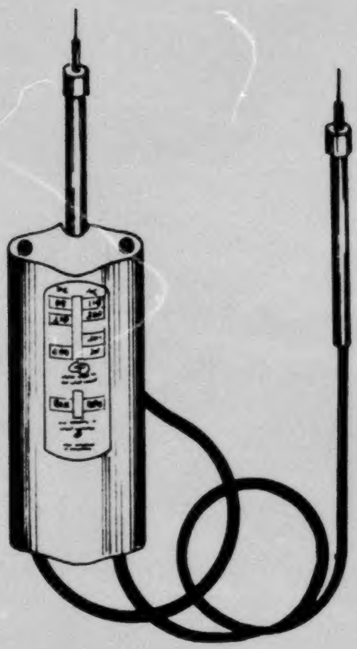
(NOTE: Calibration of a voltmeter may be done with greater accuracy when different voltage levels are used to check meters.)

I. Voltmeter



INFORMATION SHEET

J. Voltage tester



(NOTE: The voltage tester checks approximate potential and is not suitable for an accurate check of voltage.)

IV. Procedure for determining voltage drop of a service

A. Check voltage at source (transformer)

B. Check voltage at delivery point (meter)

C. Subtract delivery point reading from source reading

(NOTE: Voltage readings should be made simultaneously at the source and delivery point with meters that have been calibrated.)

V. Procedure for determining current demand on primary circuit in a specific area

A. Install three clamp-on type indicating ammeters on one circuit at substation

B. Install three clamp-on type indicating ammeters on the same circuit a few miles from substation

(NOTE: The indicating ammeters should be left on the line during an extremely hot or extremely cold period to obtain an accurate demand. The difference in readings of the two sets of meters will show current demand in the area between the two sets of meters.)

INFORMATION SHEET

VI. Procedures for determining current demand on a transformer

A. Read demand on demand meter and multiply by meter multiplier to obtain kW demand

B. Install indicating ammeter on secondary side of transformer

VII. Steps to obtain primary line voltage drop

A. Install recording voltmeter at the substation

(NOTE: The recording voltmeter may be connected to potential leads at the substation meter.)

B. Install recording voltmeter at or near the end of the primary line

(NOTE: The recording voltmeter set near the end of the line should be connected to a transformer which is not in use or connected to a potential transformer installed for the purpose of obtaining an accurate voltage reading.)

C. Subtract the voltage at the end of the primary line from the substation voltage

(NOTE: The time markings on the tape or chart of each recording voltmeter should be set to the correct time to get an accurate comparison of the two voltage readings.)

VIII. Reasons for current measurements

A. Substation ampere demand

B. Phase balance of each circuit

C. Individual circuit demand

D. Oil circuit recloser loading

E. Substation transformer and regulator loading

F. Voltage-regulator line drop compensation settings

G. Measurement of transformer loading

INFORMATION SHEET

IX. Transformer KVA ratings and full load secondary current at 240 volts single phase

KVA Rating	Current
3 KVA	12.5 amperes
5 KVA	20.83 amperes
10 KVA	41.67 amperes
15 KVA	62.50 amperes
25 KVA	104.17 amperes
37.5 KVA	156.25 amperes
50 KVA	208.33 amperes
75 KVA	312.50 amperes
100 KVA	416.67 amperes

X. Precautions to observe when making voltage and current measurements

A. Wear your protective equipment always

B. Set voltmeter on highest scale before applying to voltage

C. Attach ammeter in series with line, never in parallel

D. Do not install ammeters on a primary line by hand; always use a hot stick

E. Do not leave exposed energized connections when setting a recording meter

F. Transport and handle all instruments carefully

G. Set ammeter on high scale before checking amperage

VOLTAGE AND CURRENT MEASURING
UNIT IV

TEST

NAME ______________________________ SCORE ______________

1. Match the terms on the right to the correct definitions.

_____a. Voltmeter which gives instantaneous maximum and mininum readings

_____b. Voltmeter which records voltage and time readings on a tape or chart

_____c. Minimum and maximum voltage from a 120-volt base

_____d. Source output voltage minus the voltage at the end of the line

_____e. Time during a day when maximum line current is flowing

_____f. Meter used to calibrate instruments used for actual testing

_____g. Limit that service voltage varies from recommended base

_____h. Meter which indicates whether the line current leads or lags the voltage in electrical degrees

_____i. Meter which indicates current flow in amperes

1. Shop standard
2. Peak load
3. Indicating voltmeter
4. Voltage spread
5. Voltage levels
6. Recording voltmeter
7. Voltage drop
8. Ammeter
9. Power factor meter

2. State two purposes of voltage and current measurements.

a. ____

____

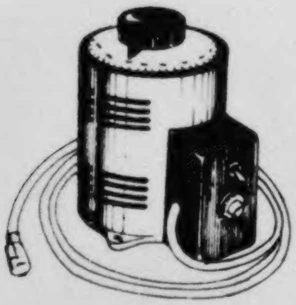
____

b. ____

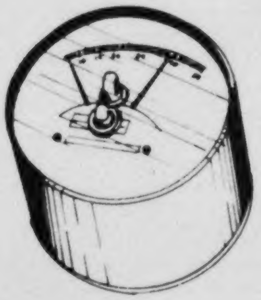
____

____

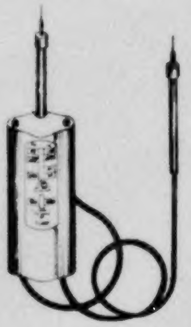
3. Identify the following voltage and current measuring equipment.



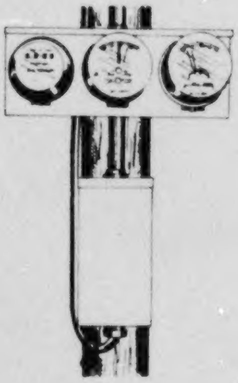
a. ____________________



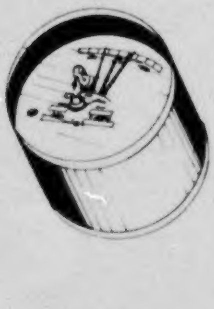
b. ____________________



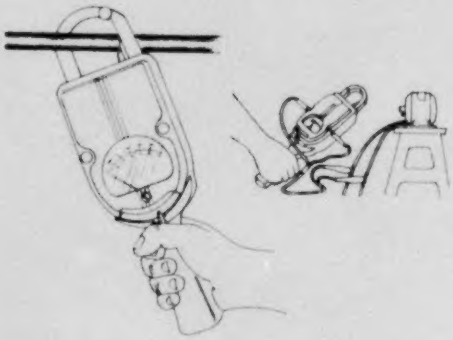
c. ____________________



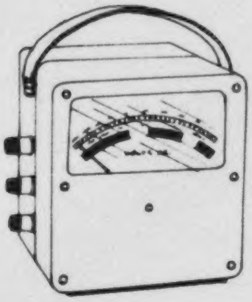
d. ____________________



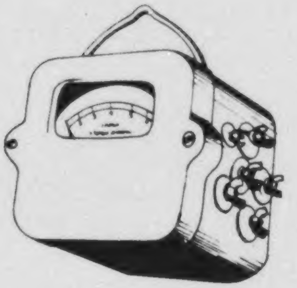
e. ____________________



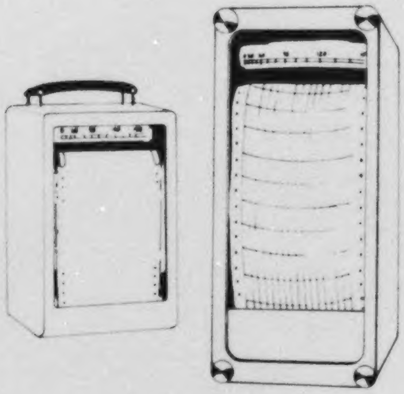
f. ____________________



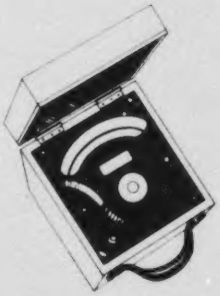
g. ____________



h. ____________



i. ____________



j. ____________

4. State the correct procedure for determining the voltage drop of a service.

a. ____

b. ____

c. ____

5. State the correct procedure for determining the current demand on a primary circuit in a specific area.

a. ____

____

b. ____

____

6. State the two procedures for determining the current demand on a transformer.

a. ______________________________

____

____

b. ______________________________

____

____

7. List the steps to obtain primary li~~ne voltag~~e drop.

a. ______________________________

____

b. ______________________________

____

c. ______________________________

____

8. Select from the following list the reasons for current measurements by placing an "X" in the blanks.

______a. Oil circuit recloser loading

______b. Placement of lightning arresters

______c. Individual circuit demand

______d. Voltage-regulator line drop compensation settings

______e. Substation transformer and regulator loading

______f. Substation ampere demand

______g. Phase balance of each circuit

______h. Measurement of transformer loading

9. Match the full load currents on the right to the KVA ratings.

_____a. 3 KVA
1. 10.3 amperes
2. 12.5 amperes

_____b. 25 KVA
1. 208.33 amperes
2. 104.17 amperes

_____c. 10 KVA
1. 20.83 amperes
2. 41.67 amperes

_____d. 100 KVA
1. 208.33 amperes
2. 416.67 amperes

_____e. 75 KVA
1. 312.50 amperes
2. 208.33 amperes

_____f. 5 KVA
1. 20.83 amperes
2. 41.67 amperes

_____g. 37.5 KVA
1. 156.25 amperes
2. 208.33 amperes

_____h. 50 KVA
1. 208.33 amperes
2. 156.25 amperes

_____i. 15 KVA
1. 41.67 amperes
2. 62.50 amperes

10. Select from the following list precautions to observe when making voltage and current measurements.

_____a. Attach ammeter in series with line, never in parallel

_____b. Wear your protective equipment always

_____c. Do not leave exposed energized connections when setting a recording meter

_____d. Do not install ammeters on a primary line by hand; always use a hot stick

_____e. Set voltmeter on highest scale before applying to voltage

_____f. Attach voltmeter in series with line

_____g. Transport and handle all instruments carefully

_____h. Set ammeter on high scale before checking amperage

VOLTAGE AND CURRENT MEASURING
UNIT IV

ANSWERS TO TEST

1. Match the terms on the right to the correct definitions.

_3_ a. Voltmeter which gives instantaneous maximum and minimum readings

_6_ b. Voltmeter which records voltage and time readings on a tape or chart

_5_ c. Minimum and maximum voltage from a 120-volt base

_7_ d. Source output voltage minus the voltage at the end of the line

_2_ e. Time during a day when maximum line current is flowing

_1_ f. Meter used to calibrate instruments used for actual testing

_4_ g. Limit that service voltage varies from recommended base

_9_ h. Meter which indicates whether the line current leads or lags the voltage in electrical degrees

_8_ i. Meter which indicates current flow in amperes

1. Shop standard
2. Peak load
3. Indicating voltmeter
4. Voltage spread
5. Voltage levels
6. Recording voltmeter
7. Voltage drop
8. Ammeter
9. Power factor meter

2. State two purposes of voltage and current measurements.

   a. Provide valuable information for the operation and development of an electrical system

   b. Provide basic data for maintaining adequate voltage levels and current balance

3. Identify the following voltage and current measuring equipment.

   a. Variable voltage source

   b. Socket type indicating ammeter

   c. Voltage tester

   d. Kilowatt-hour, volt, and ammeter test block

   e. Socket type voltmeter

- f. Clamp-on volt-ammeter
- g. Voltmeter
- h. Primary line ammeter
- i. Recording voltmeter
- j. Shop standard voltmeter

4. State the correct procedure for determining the voltage drop of a service.
   - a. Check voltage at source (transformer)
   - b. Check voltage at delivery point (meter)
   - c. Subtract delivery point reading from source reading

5. State the correct procedure for determining the current demand on a primary circuit in a specific area.
   - a. Install three clamp-on type indicating ammeters on one circuit at substation
   - b. Install three clamp-on type indicating ammeters on the same circuit a few miles from substation

6. State the two procedures for determining the current demand on a transformer.
   - a. Read demand on demand meter and multiply by meter multiplier to obtain kW demand
   - b. Install indicating ammeter on secondary side of transformer

7. List the steps to obtain primary line voltage drop.
   - a. Install recording voltmeter at the substation
   - b. Install recording voltmeter at or near the end of the primary line
   - c. Subtract the voltage at the end of the primary line from the substation voltage

8. Select from the following list the reasons for current measurements by placing an "X" in the blanks.

   __X__ a. Oil circuit recloser loading

   _____ b. Placement of lightning arresters

   __X__ c. Individual circuit demand

   __X__ d. Voltage-regulator line drop compensation settings

X e. Substation transformer and regulator loading

X f. Substation ampere demand

X g. Phase balance of each circuit

X h. Measurement of transformer loading

9. Match the full load currents on the right to the KVA ratings.

2 a. 3 KVA
    1. 10.3 amperes
    2. 12.5 amperes

2 b. 25 KVA
    1. 208.33 amperes
    2. 104.17 amperes

2 c. 10 KVA
    1. 20.83 amperes
    2. 41.67 amperes

2 d. 100 KVA
    1. 208.33 amperes
    2. 416.67 amperes

1 e. 75 KVA
    1. 312.50 amperes
    2. 208.33 amperes

1 f. 5 KVA
    1. 20.83 amperes
    2. 41.67 amperes

1 g. 37.5 KVA
    1. 156.25 amperes
    2. 208.33 amperes

1 h. 50 KVA
    1. 208.33 amperes
    2. 156.25 amperes

2 i. 15 KVA
    1. 41.67 amperes
    2. 62.50 amperes

10. Select from the following list precautions to observe when making voltage and current measurements.

X a. Attach ammeter in series with line, never in parallel

X b. Wear your protective equipment always

X c. Do not leave exposed energized connections when setting a recording meter

X d. Do not install ammeters on a primary line by hand; always use a hot stick

X e. Set voltmeter on highest scale before applying to voltage

____ f. Attach voltmeter in series with line

X g. Transport and handle all instruments carefully

X h. Set ammeter on high scale before checking amperage

METERS AND METER APPLICATION
UNIT I

UNIT OBJECTIVE

After completion of this unit, the student should be able to match terms and symbols used with metering to the correct meanings. The student should be able to select meters for various applications and be able to calculate multipliers for meters. This knowledge will be evidenced through demonstration and by scoring 85 percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms commonly associated with metering to the correct definitions.
2. List general types of meters.
3. List types of meters by base construction.
4. List classes of meters and the current capacity of each.
5. Match meters to types of service.
6. Match meter voltage ratings to types of service.
7. Match symbols used with metering circuit diagrams to the correct meanings.
8. List uses of current transformer metering.
9. List uses of self-contained meters.
10. Identify various self-contained meter connections.
11. Identify various transformer-rated meter connections.
12. Identify various transformer-rated meter connections for 600 volts or above.
13. State procedure for selecting correct meter.
14. List methods for determining voltage for wye and delta connected meters.
15. Match types of services to specific uses.
16. List types of meters which have multipliers.

17. Arrange in order the correct procedure for determining meter multipliers.

18. List precautions to observe with metering.

19. Calculate meter multipliers.

METERS AND METER APPLICATION
UNIT I

SUGGESTED ACTIVITIES

I. Suggested activities for instructor:

   A. Provide student with objective sheet.

   B. Provide student with information and assignment sheets.

   C. Make transparencies.

   D. Discuss unit and specific objectives.

   E. Discuss information and assignment sheets.

   F. Show films and other supplemental material on metering.

   G. Give test.

II. Unit references:

   A. Rural Electrification Administration. *Application Guide for Watt-hour Meters.* REA Bulletin 161-12. Washington, D.C.: U.S. Department of Agriculture, March 1964.

   (NOTE: This publication is available from Superintendent of Documents, Government Printing Office, Washington, D.C. 20402.)

   B. *Meter and Instrument Transformer Guide and Condensed Metering Course: All in One.* Raleigh, North Carolina: Westinghouse Electric Corp./Meter Div., no date.

METERS AND METER APPLICATION
UNIT I

INFORMATION SHEET

I. Terms and definitions

A. Power--Rate at which an electrical circuit performs work

B. Energy--Power multiplied by time

Example: Power in a circuit = 5 kW
Amount of time power is used = 2 hours
2 x 5 = 10 kilowatt-hours

C. Watt-hour meter--Instrument which measures electrical energy

D. Register--Gear train arranged to count the revolutions of a meter disc (Transparency 1)

E. Watt-hour--One watt for one hour

F. Kilowatt-hour--One thousand watts for one hour

G. Stator--Stationary part of a meter which produces a magnetic flux that causes the meter disc to turn (Transparency 2)

H. Damping system--Magnet or magnets which cause a retarding force on the meter disc

I. Demand--Power requirements (kW) over a period of time, usually 15 or 30 minutes

J. Detent--Device installed on a meter to prevent the meter from running backwards when current flow through the meter is reversed

K. Uni-directional register--Meter register which registers energy even if meter is installed upside down

L. Potential indicator--Small lamp that indicates the presence of voltage on the potential coil

M. Polyphase meter--Combination of single-phase meter stators in a single unit (Transparency 3)

N. Class--Maximum current-carrying capability of a meter

O. Self-contained meter--Meter which carries entire load of current through its current coils

P. Transformer-rated meter--Meter that is used with current transformers to measure electrical energy

INFORMATION SHEET

- Q. K_h (meter constant)--Watt-hours per revolution of the meter disc
- R. R_r (register ratio)--Ratio of revolutions of the first register shaft to each revolution of the first pointer shaft (Transparency 4)
- S. First reduction--Ratio of revolutions of the meter disc to one revolution of the first register shaft (Transparency 1)
- T. Current transformer ratio--Relationship of current flow through a current transformer to the output current

  Example: Current transformer rating 200 to 5
  Ratio = Current capacity divided by output current
  $\frac{200}{5}$ = 40 to 1 ratio

  (NOTE: A current flow through a 200 to 5 current transformer of 40 amperes will induce one ampere of output current which flows through and is registered by the kilowatt-hour meter. The meter reading would be multiplied by 40 to get the correct amount of energy used.)

II. General types of meters

- A. Self-contained
- B. Transformer-rated

III. Meter types by base construction

- A. Socket base ("S" base)
- B. Bottom connected ("A" base)

IV. Meter classes and current carrying capacities

- A. Class 10--Maximum current of 10 amperes
- B. Class 20--Maximum current of 20 amperes
- C. Class 100--Maximum current of 100 amperes
- D. Class 200--Maximum current of 200 amperes

V. Meter coordination with service types

- A. Single-phase two-wire service--Use two-wire meter
- B. Single-phase three-wire service--Use three-wire meter
- C. Three-phase three-wire delta service--Use three-wire delta meter

INFORMATION SHEET

D. Three-phase four-wire delta service--Use four-wire delta meter

E. Three-phase four-wire wye service--Use four-wire wye meter

(NOTE: The amperage or class of meter to be used is determined by the size of the transformer and service and the consumer's load requirements. The meter should be large enough to carry the heaviest load the consumer will have.)

VI. Voltage rating of meters for various services

A. Single-phase two-wire service--Voltage rating is the same as phase-to-ground voltage of service

Example: 120-volt two-wire service uses 120-volt two-wire meter

B. Single-phase three-wire service--Voltage rating is the same as phase-to-phase voltage

Example: 120/240-volt three-wire service uses 240-volt three-wire meter

C. Three-phase three-wire delta service--Voltage rating is phase-to-phase voltage of service

Example: 480-volt three-wire three-phase service uses 480-volt three-wire three-phase meter

D. Three-phase four-wire delta service--Voltage rating is the same as phase-to-phase voltage

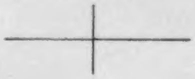
Example: 120/240-volt four-wire service uses 240-volt four-wire meter

E. Three-phase four-wire wye service--Voltage rating is the same as phase-to-ground voltage

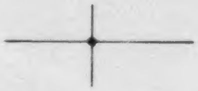
Examples: 120/208-volt four-wire service uses 120-volt four-wire wye meter; 277/480-volt four-wire wye service uses 240-volt four-wire wye meter

VII. Symbols used with metering circuit diagrams

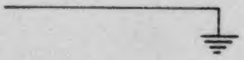
A. No connection



B. Solid connection



INFORMATION SHEET

C. Ground 

D. Potential transformer **PT**

(NOTE: This is the abbreviation.)

E. Current transformer **CT**

F. Current connection **C_1**

G. Potential connection **P_1**

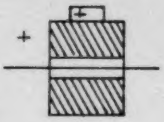
H. Ground connection **G**

I. Neutral connection **N**

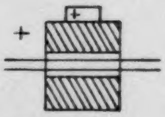
J. Self-contained **SC**

K. Transformer-rated **TR**

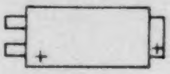
L. Two-wire current transformer



M. Three-wire current transformer

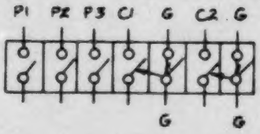


N. Potential transformer

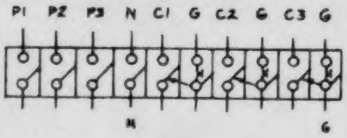


(NOTE: The polarity marks on current and potential transformers vary in type. The marks may be white dots or other markings.)

O. Seven pole test block



P. Ten pole test block



Q. Delta connected △

R. Wye connected **Y**

INFORMATION SHEET

VIII. Current transformer metering uses

- A. Loads greater than 200 amperes
- B. Voltages of 480 or higher
- C. Locations where it would be impractical to install a large metering conductor

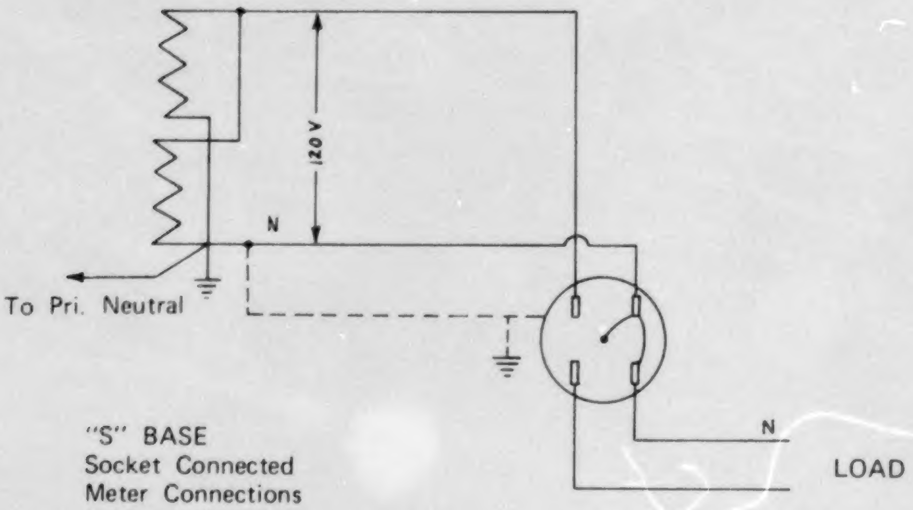
IX. Uses of self-contained meters

- A. Loads of 200 amperes or less
- B. Voltages of 480 volts or less

  (NOTE: It is recommended that current transformer metering be used on 480-volt services; however, 480-volt self-contained meters are used on small 480-volt loads.)

X. Self-contained meter connections

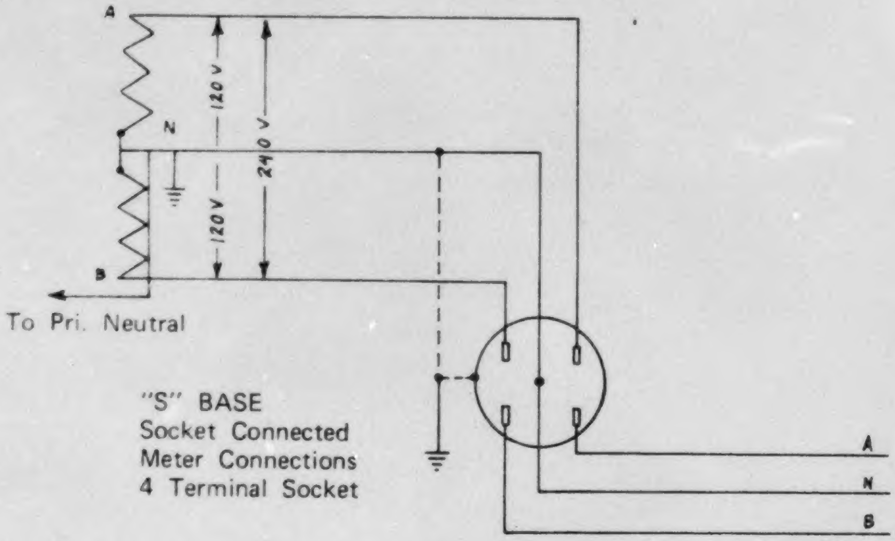
- A. Two-wire single-phase 120-volt service



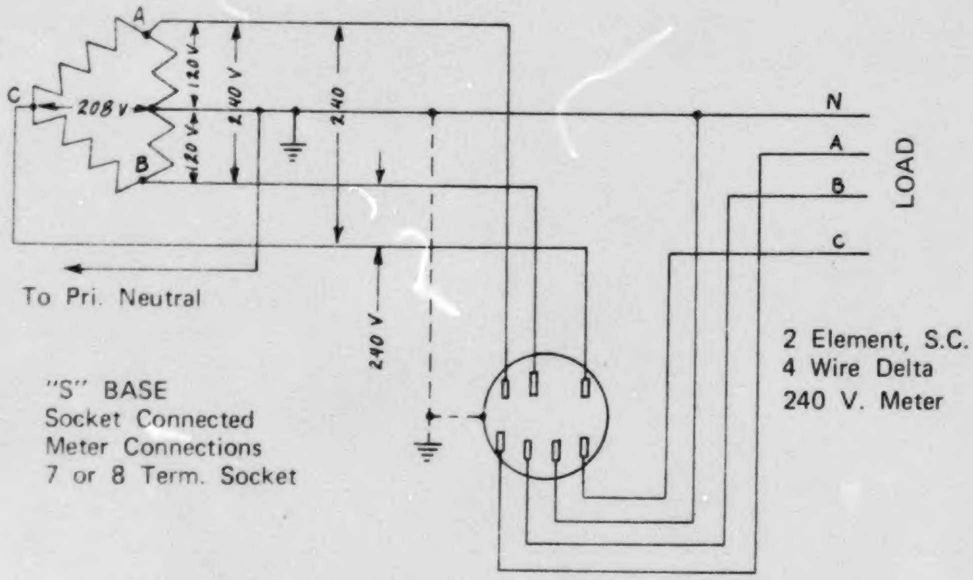
"S" BASE
Socket Connected
Meter Connections
4 Terminal Socket

INFORMATION SHEET

B. Three-wire single-phase 120/240-volt service

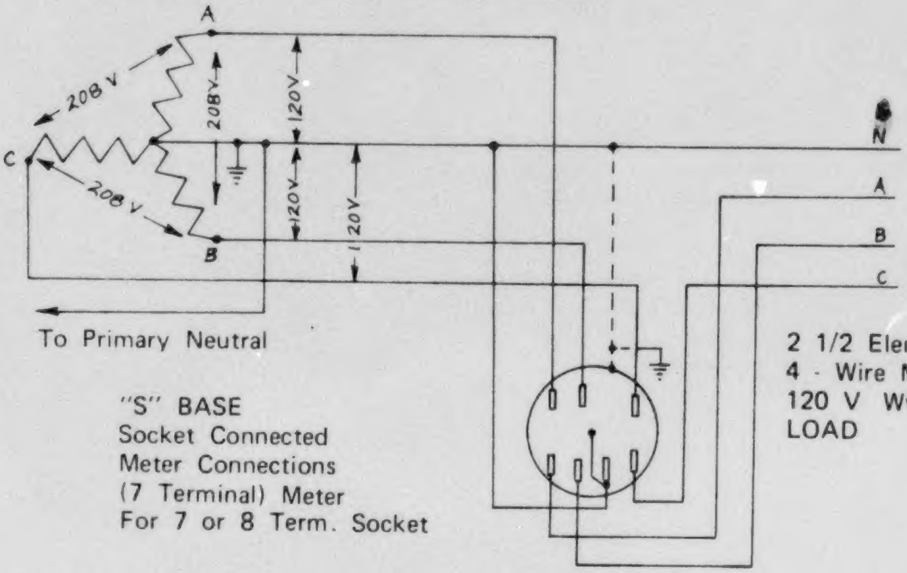


C. Four-wire three-phase 120/240-volt delta service



INFORMATION SHEET

D. Four-wire three-phase 120/208-volt wye service

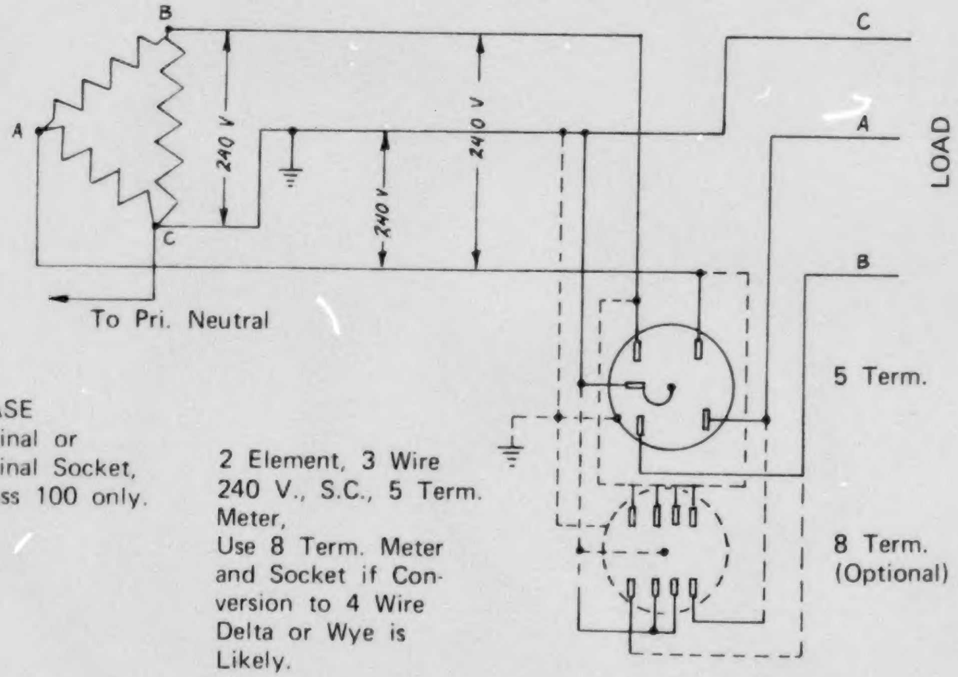


To Primary Neutral

"S" BASE
Socket Connected
Meter Connections
(7 Terminal) Meter
For 7 or 8 Term. Socket

2 1/2 Element,
4 - Wire Meter
120 V Wye
LOAD

E. Three-wire three-phase 240-volt corner ground delta service



To Pri. Neutral

"S" BASE
5 Terminal or
8 Terminal Socket,
For Class 100 only.

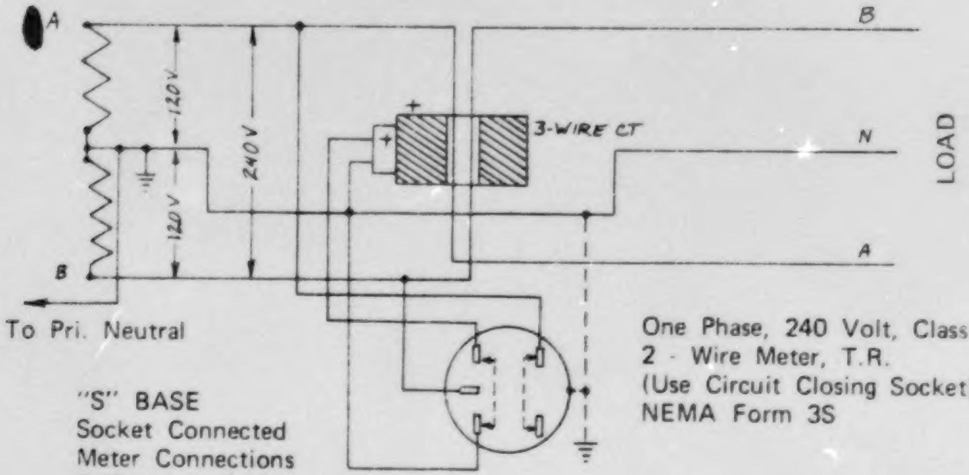
2 Element, 3 Wire
240 V., S.C., 5 Term.
Meter,
Use 8 Term. Meter
and Socket if Conversion to 4 Wire
Delta or Wye is
Likely.

(NOTE: This metering method is also used with 480-volt three-wire service.)

INFORMATION SHEET

XI. Transformer-rated meter connections

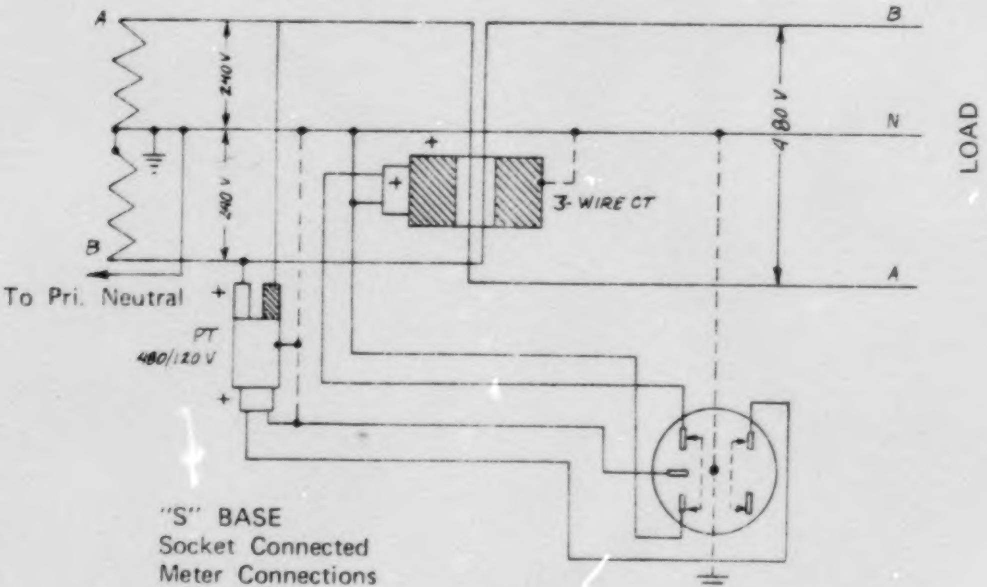
A. Three-wire single-phase 120/240-volt service



One Phase, 240 Volt, Class 10
2 - Wire Meter, T.R.
(Use Circuit Closing Socket)
NEMA Form 3S

"S" BASE
Socket Connected
Meter Connections
5 Terminal Socket

B. Three-wire single-phase 240/480-volt service

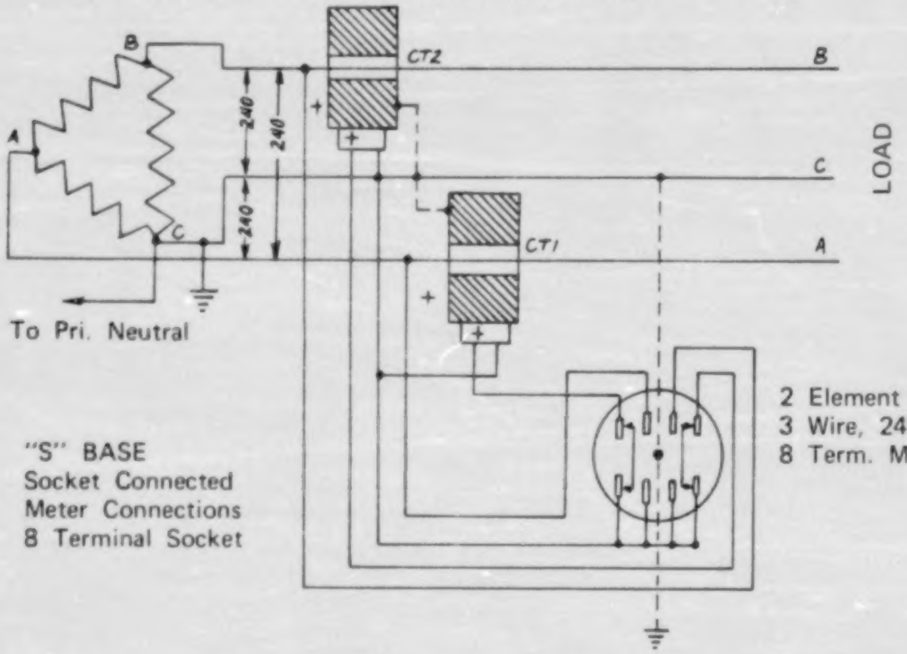


"S" BASE
Socket Connected
Meter Connections
5 Term. Socket

1 - Phase, 120 Volt, T.R.
Class 10, 2 - Wire Meter
(Use Circuit Closing Socket)

INFORMATION SHEET

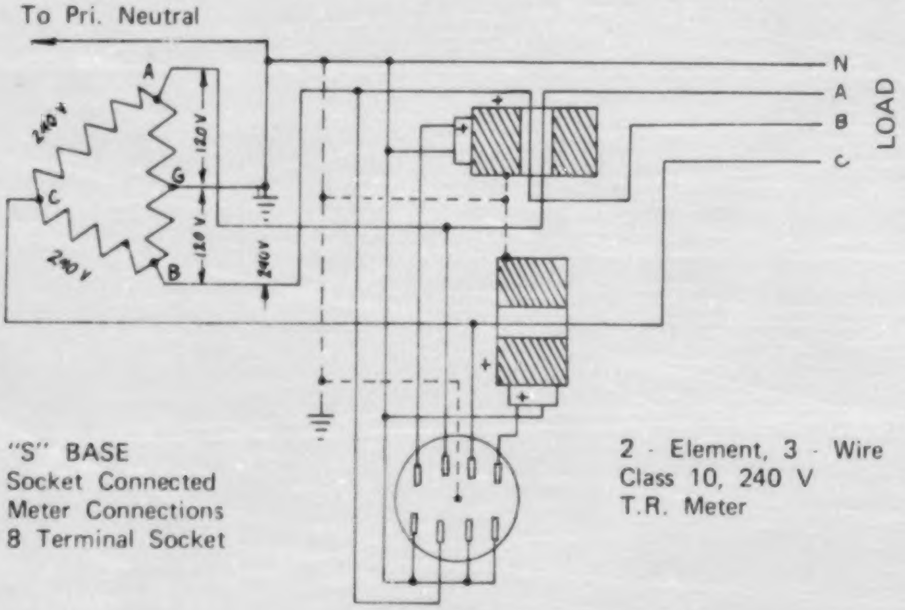
C. Three-wire three-phase 240-volt delta service



"S" BASE
Socket Connected
Meter Connections
8 Terminal Socket

2 Element
3 Wire, 240 V., T.R.
8 Term. Meter

D. Four-wire three-phase 120/240-volt delta service



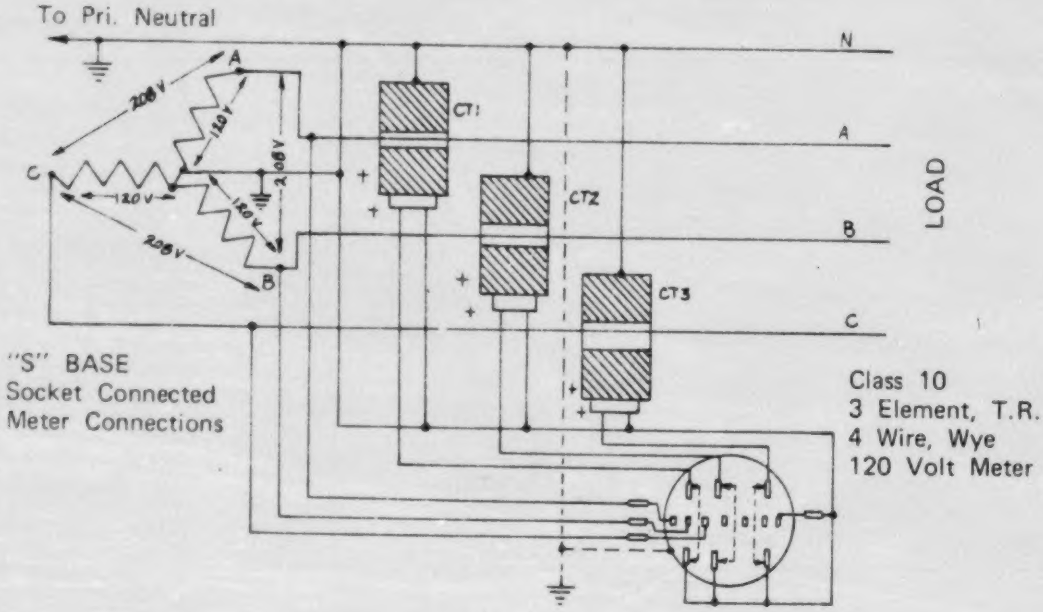
"S" BASE
Socket Connected
Meter Connections
8 Terminal Socket

2 - Element, 3 - Wire
Class 10, 240 V
T.R. Meter

INFORMATION SHEET

E. Four-wire three-phase 120/208-volt wye service

(NOTE: This connection is also used with a 277/480-volt service by using a 240-volt meter.)



"S" BASE
Socket Connected
Meter Connections

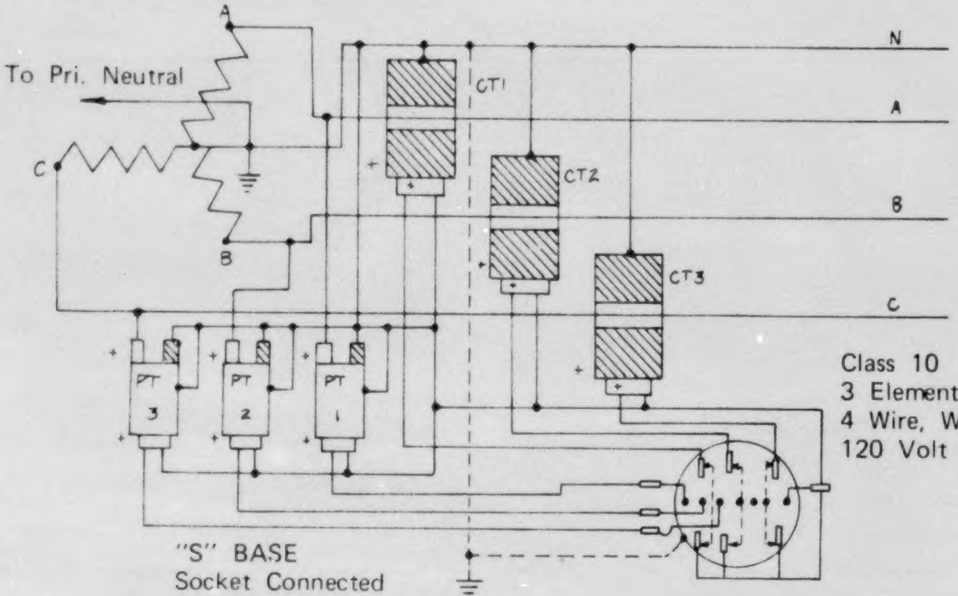
Class 10
3 Element, T.R.
4 Wire, Wye
120 Volt Meter

(NOTE: All of the metering connections shown may be installed with a bottom connected "A" base meter. Whichever method is used, the wiring diagrams must be followed precisely to avoid costly errors in the meter registration.)

INFORMATION SHEET

XII. Transformer-rated meter connections for voltages above 600 volts

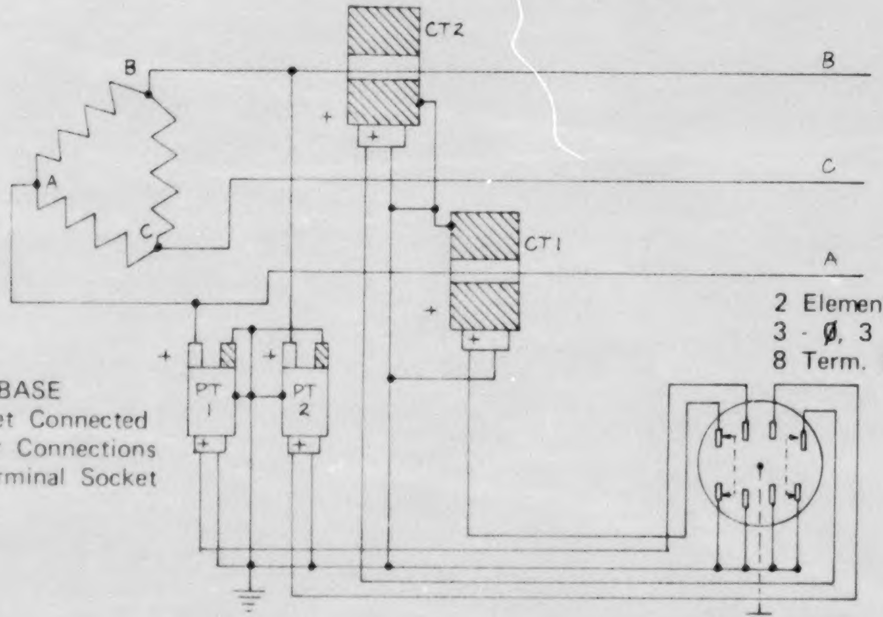
A. Four-wire three-phase wye primary metering



Class 10
3 Element, T.R.
4 Wire, Wye,
120 Volt Meter

"S" BASE
Socket Connected
Meter Connections

B. Three-wire three-phase delta primary metering



2 Element, T.R.
3 - Ø, 3 Wire
8 Term. Meter

"S" BASE
Socket Connected
Meter Connections
8 Terminal Socket

INFORMATION SHEET

XIII. Procedure for selecting correct meter

A. Determine class of meter needed

B. Determine voltage to be metered

C. Determine phase of meter

Example: Single or three

D. Determine service connection

Example: Wye or delta

E. Determine wires of meter

Examples: 2, 3, 4

XIV. Methods to determine correct meter voltage rating

A. Wye-connected service--Meter voltage will be line-to-ground voltage of service

B. Delta-connected service--Meter voltage will be line-to-line voltage of service

(NOTE: An exception to the methods listed is the meter for 277/480-volt wye-connected service. Even though the line-to-ground voltage is 277 volts, the meter voltage for this application is 240 volts.)

XV. Types of services and their uses

A. Two-wire single-phase 120-volt service--Billboards, shallow well pumps, and small dwellings

B. Three-wire single-phase 120/240-volt service--Most residences and small industrial locations

C. Four-wire three-phase 120/240-volt delta service--Residences where three-phase power is needed for heating or air conditioning and industrial locations where small three-phase power is needed with large light loads

D. Three-wire three-phase 240 or 480 volt delta service--Power loads only for oil field and irrigation pumps

E. Four-wire three-phase 120/208-volt wye service--Apartment complexes where both light and power loads may be heavy

F. Four-wire three-phase 277/480-volt wye service--Commercial and industrial areas where long circuit distances can be made with small conductor

XVI. Meters which have multipliers

A. All transformer-rated meters

B. Some self-contained meters used on heavy loads

INFORMATION SHEET

XVII. Procedure to determine meter multiplier for secondary-rated meter used with PTs and CTs

A. Record information from meter nameplate and meter register, K_h and R_r

B. Record ratios from current transformer and potential transformer

C. Record first gear reduction given by meter manufacturer

D. Multiply meter constant x register ratio x CT ratio x PT ratio x first gear reduction and divide product by 10,000

Example:

Meter Kh = 1.8
Meter Rr = 55 5/9
CT ratio = 50:5
PT ratio = 60:1
First gear reduction = 100:1

18/10 x 500/9 x 50/5 x 60/1 x 100/1 =

$$\frac{6,000,000}{10,000} = 600$$

Meter multiplier = 600

(NOTE: The multiplier for a secondary-rated meter may be calculated by multiplying 1 x CT ratio if the meter has not had any parts changed. It is better to figure the multiplier on all transformer-rated meters using all components to avoid errors in the calculation.)

XVIII. Precautions to observe with metering

A. Wear eye protection

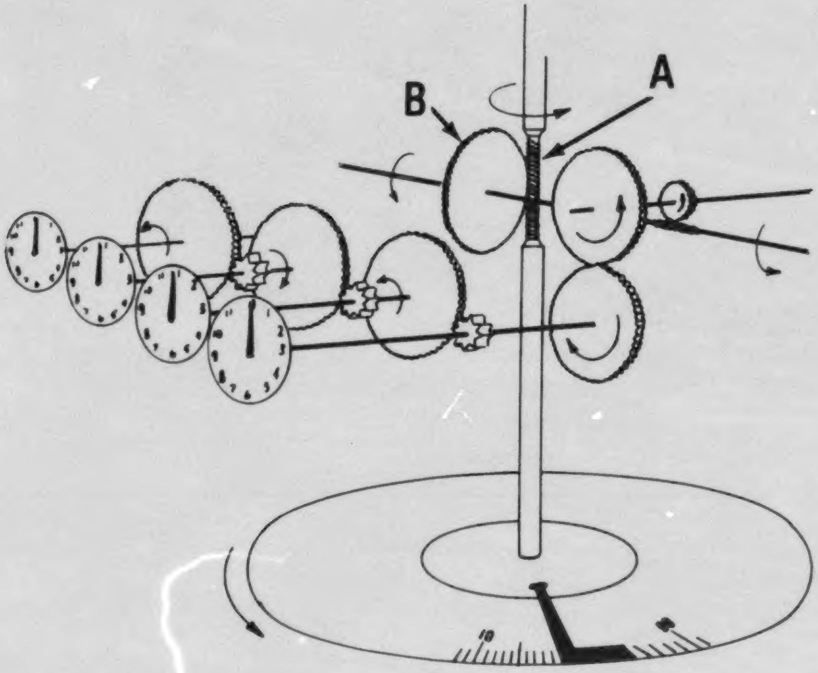
B. Wear your rubber gloves

C. Do not remove a meter which is under load

D. Short circuit the secondary side of current transformers before removing the meter

(NOTE: An open secondary circuit connected to a current transformer on an energized conductor can develop high voltage which is dangerous to personnel and equipment.)

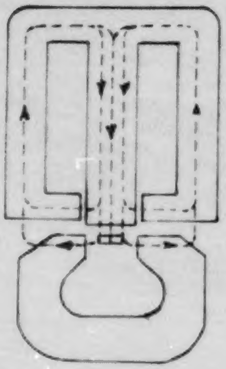
Meter Register



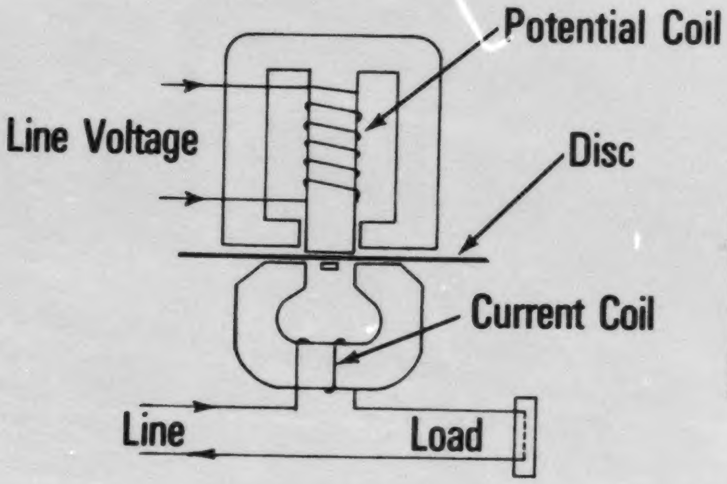
First Reduction

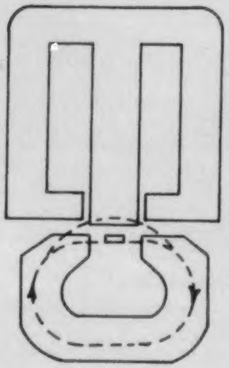
Revolutions of worm drive "A" to
one revolution of gear "B"
(Usually 100 to 1 or 50 to 1)

Watt-Hour Meter Stator



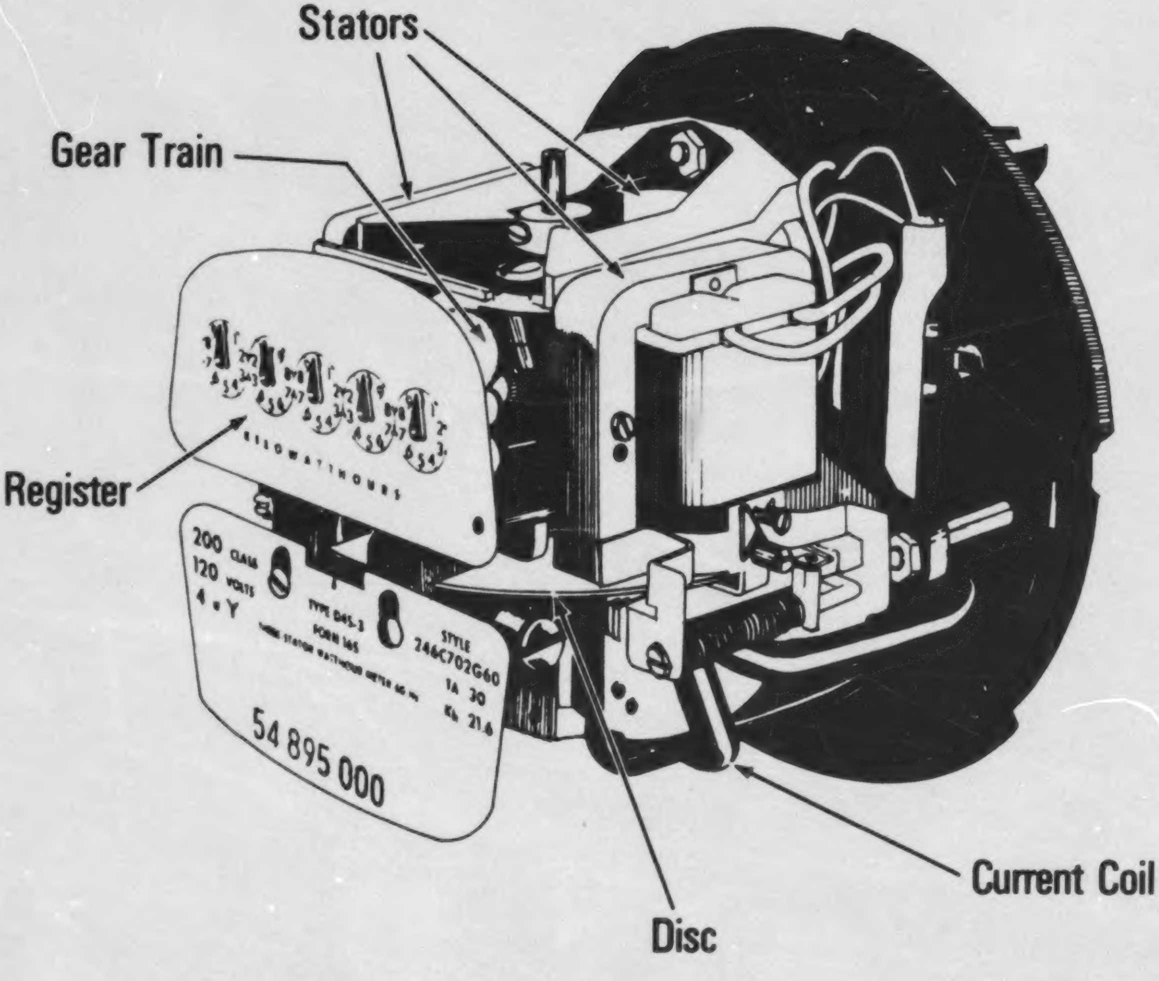
Potential Coil
Magnetic Flux



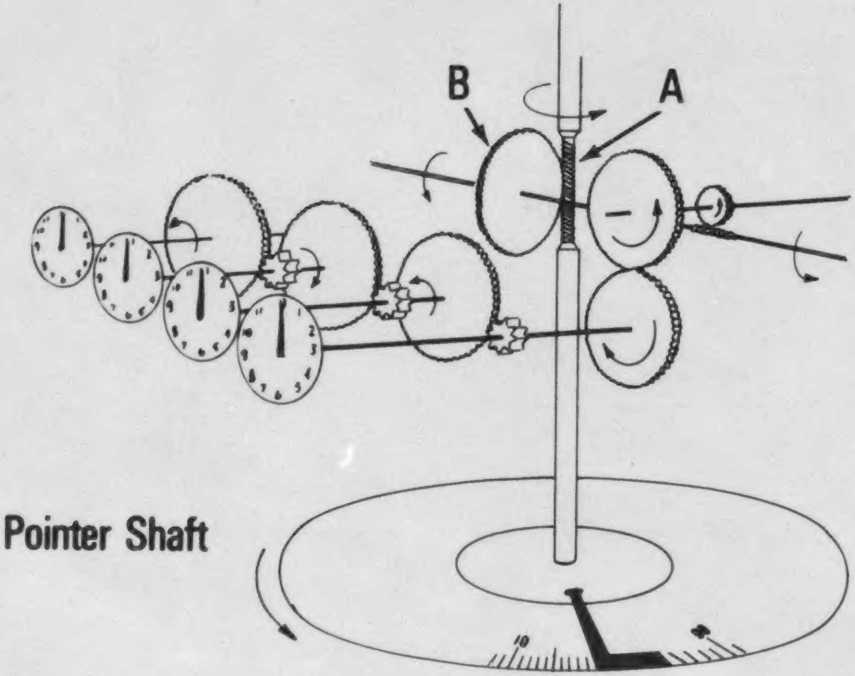


Current Coil
Magnetic Flux

Polyphase Meter



Register Ratio



First Pointer Shaft

R_r Reduction From A To B

METERS AND METER APPLICATION
UNIT I

ASSIGNMENT SHEET #1--CALCULATE THE MULTIPLIER FOR TRANSFORMER-RATED METER CONNECTED TO SECONDARY LINE

Use the following information from meter nameplate and register and use 400:5 current transformer ratio.

R_r = 55 5/9

K_h = 1.8

G_r = 100:1

CT ratio = 400:5

Multiply $R_r \times K_h \times G_r \times CT_r$ and divide by 10,000

METERS AND METER APPLICATION
UNIT I

ASSIGNMENT SHEET #2--CALCULATE THE MULTIPLIER FOR A TRANSFORMER-RATED METER CONNECTED TO A PRIMARY LINE

Use the following information from meter nameplate and register and use 25:5 current transformer ratio and use 60:1 potential transformer ratio.

R_r = 166 2/3

K_h = 1.8

G_r = 50:1

CT ratio = 10:5

PT ratio = 60:1

Multiply $R_r \times K_h \times G_r \times CT_r \times PT_r$ and divide by 10,000

METERS AND METER APPLICATION
UNIT I

ANSWERS TO ASSIGNMENT SHEETS

Assignment Sheet #1

R_r = 55 5/9 = 500/9

K_h = 1.8 = 18/10

G_r = 100:1 = 100/1

CT ratio = 400:5 = 400/5

500/9 x 18/10 x 100/1 x 400/5 = 800,000

$$\frac{800{,}000}{10{,}000} = 80$$

Meter multiplier is 80

Assignment Sheet #2

R_r = 166 2/3 = 500/3

K_h = 1.8 = 18/10

G_r = 50:1 = 50/1

CT_r = 10:5 = 10/5

PT_r = 60:1 = 60/1

500/3 x 18/10 x 50/1 x 10/5 x 60/1 = 1,800,000

$$\frac{1{,}800{,}000}{10{,}000} = 180$$

Meter multiplier is 180

METERS AND METER APPLICATION
UNIT I

TEST

NAME ______________________________ SCORE ____________________

1. Match the terms on the right to the correct definitions. (Terms and definitions are continued on the following page. Answers for "a" through "m" are on this page.)

_____a. Rate at which an electrical circuit performs work

_____b. Power multiplied by time

_____c. Instrument which measures electrical energy

_____d. Gear train arranged to count the revolutions of a meter disc

_____e. One watt for one hour

_____f. One thousand watts for one hour

_____g. Stationary part of a meter which produces a magnetic flux that causes the meter disc to turn

_____h. Magnet or magnets which cause a retarding force on the meter disc

_____i. Power requirements (kW) over a period of time, usually 15 or 30 minutes

_____j. Device installed on a meter to prevent meter from running backwards when current flow through the meter is reversed

_____k. Meter register which registers energy even if meter is installed upside down

_____l. Small lamp that indicates the presence of voltage on the potential coil

_____m. Combination of single-phase meter stators in a single unit

1. Demand
2. Uni-directional register
3. Watt-hour meter
4. Damping system
5. Detent
6. Power
7. Kilowatt-hour
8. Stator
9. Watt-hour
10. Energy
11. Register
12. Polyphase meter
13. Potential indicator

______n. Maximum current-carrying capability of a meter

______o. Meter which carries entire load of current through its current coils

______p. Meter that is used with current transformers to measure electrical energy

______q. Watt-hours per revolution of the meter disc

______r. Ratio of revolutions of the first register shaft to each revolution of the first pointer shaft

______s. Ratio of revolutions of the meter disc to one revolution of the first register shaft

______t. Relationship of current flow through a current transformer to the output current

14. First reduction
15. Current transformer ratio
16. Transformer-rated meter
17. Self-contained meter
18. K_h (meter constant)
19. R_r (register ratio)
20. Class

2. List two general types of meters.

   a. ____

   b. ____

3. List two types of meters by base construction.

   a. ____

   b. ____

4. List four classes of meters and the current-carrying capacity of each.

   a. ____

   b. ____

   c. ____

   d. ____

5. Match the meters on the right to the correct service type.

_____a. Three-phase four-wire delta
_____b. Three-phase four-wire wye
_____c. Single-phase two-wire
_____d. Three-phase three-wire delta
_____e. Single-phase three-wire

1. Four-wire wye
2. Four-wire delta
3. Three-wire
4. Three-wire delta
5. Two-wire

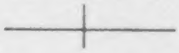
6. Match the meter voltage ratings on the right to the correct types of service.

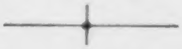
_____a. Single-phase two-wire
_____b. Single-phase three-wire
_____c. Three-phase three-wire delta
_____d. Three-phase four-wire delta
_____e. Three-phase four-wire wye

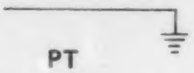
1. Phase-to-ground
2. Phase-to-phase

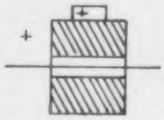
7. Match the abbreviations and symbols on the right to the correct meanings.

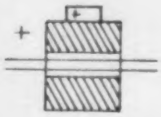
_____a. Potential transformer (symbol)
_____b. Ten pole test block
_____c. Potential transformer
_____d. Current transformer
_____e. Delta connected
_____f. Ground
_____g. Two-wire current transformer
_____h. Ground connection
_____i. Solid connection
_____j. Self-contained
_____k. Three-wire current transformer
_____l. Transformer-rated
_____m. Neutral connection
_____n. Current connection

1. 

2. 

3. 

4. PT
5. CT
6. C_1
7. P_1
8. G
9. N
10. SC
11. TR
12. 

13. 

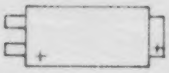
_____o. Seven pole test block

_____p. Wye connected

_____q. Potential connection

_____r. No connection

14.



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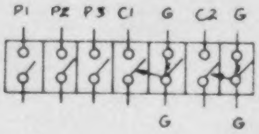
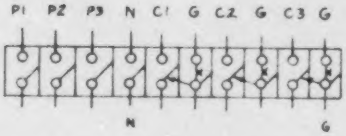


16.



17. △

18. Y

8. List three uses of current transformer metering.

a. ______________________________

b. ______________________________

c. ______________________________

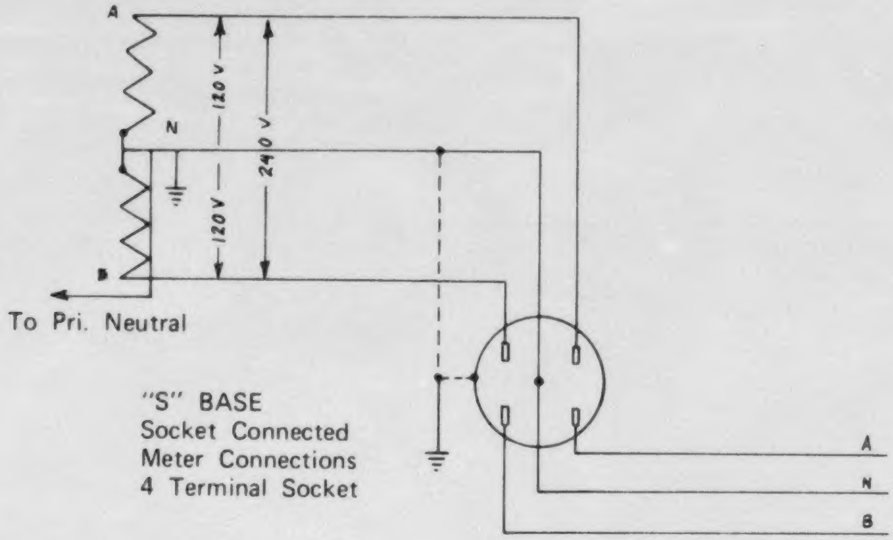
____

9. List two uses of self-contained meters.

a. ______________________________

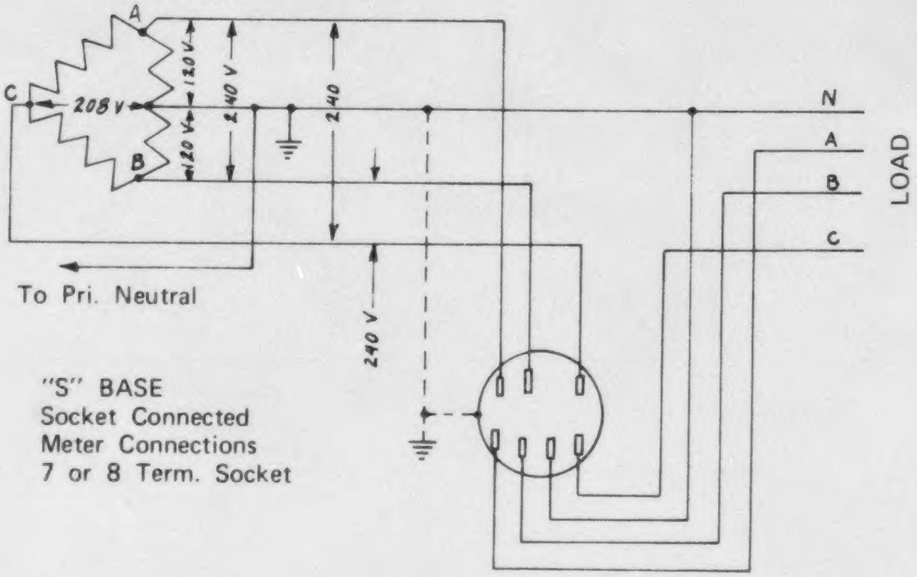
b. ______________________________

10. Identify the following self-contained meter connections.



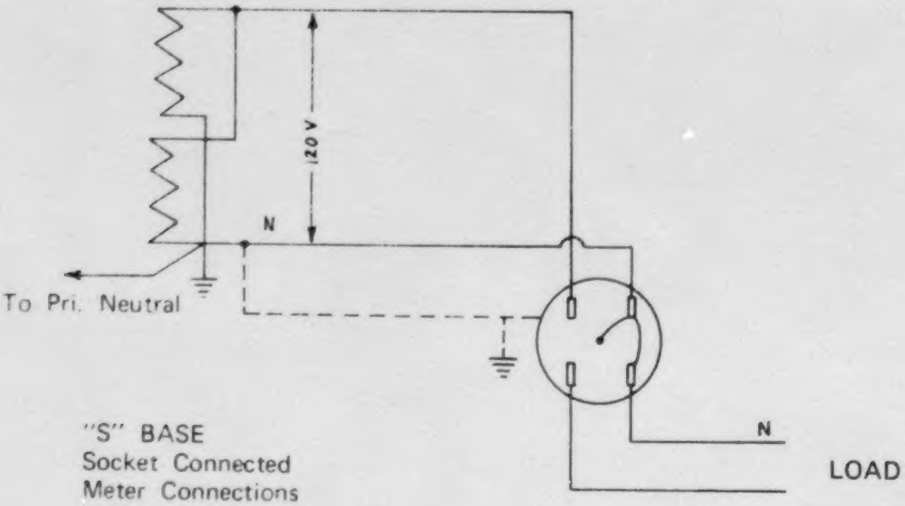
"S" BASE
Socket Connected
Meter Connections
4 Terminal Socket

a. ______________________________



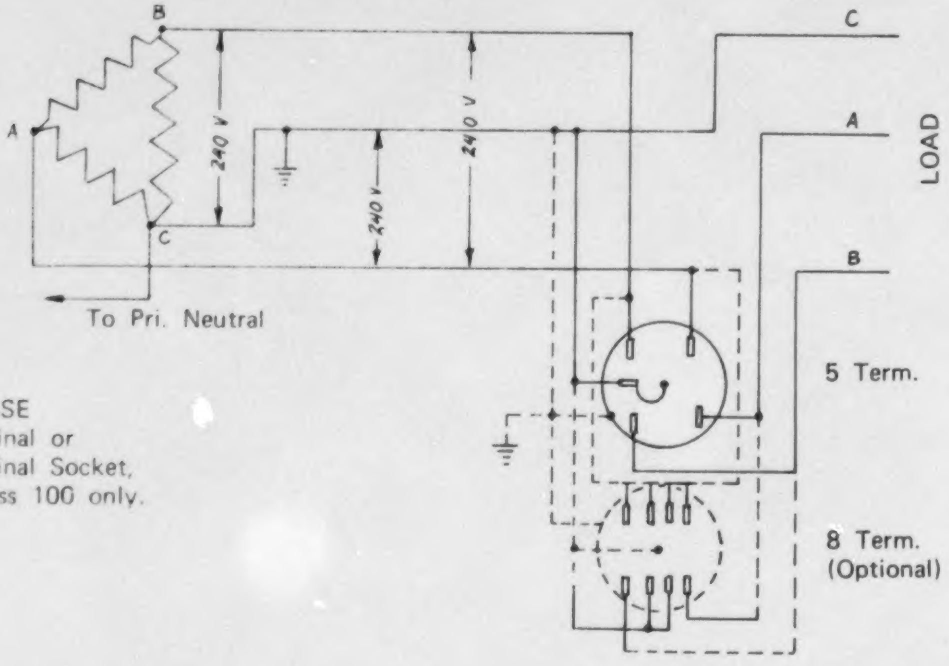
"S" BASE
Socket Connected
Meter Connections
7 or 8 Term. Socket

b. ______________________________



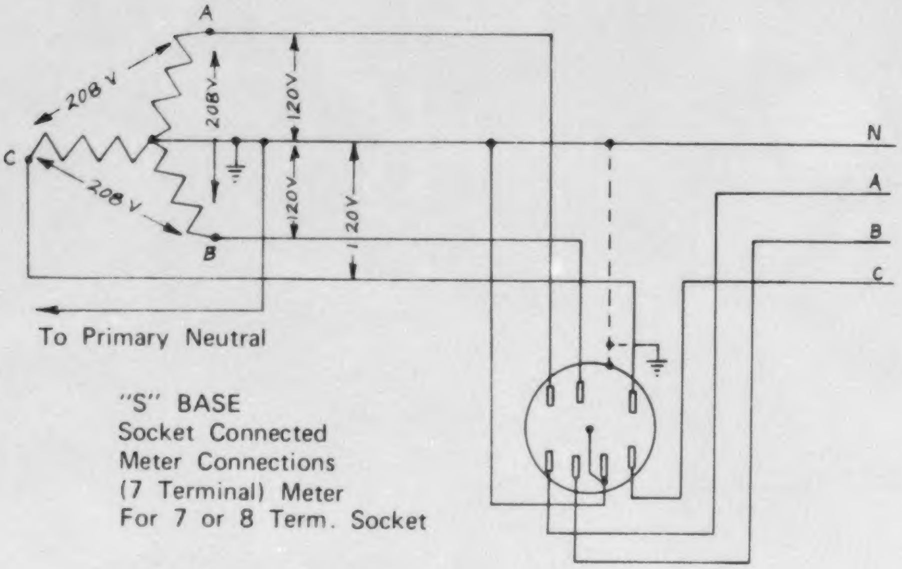
"S" BASE
Socket Connected
Meter Connections
4 Terminal Socket

c. ______________________________



"S" BASE
5 Terminal or
8 Terminal Socket,
For Class 100 only.

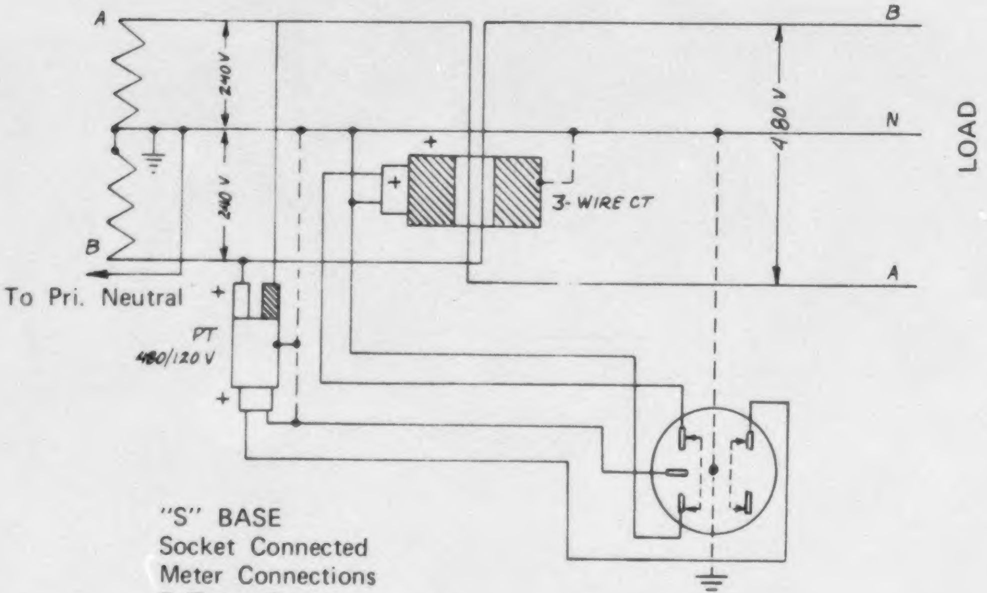
d. ______________________________



"S" BASE
Socket Connected
Meter Connections
(7 Terminal) Meter
For 7 or 8 Term. Socket

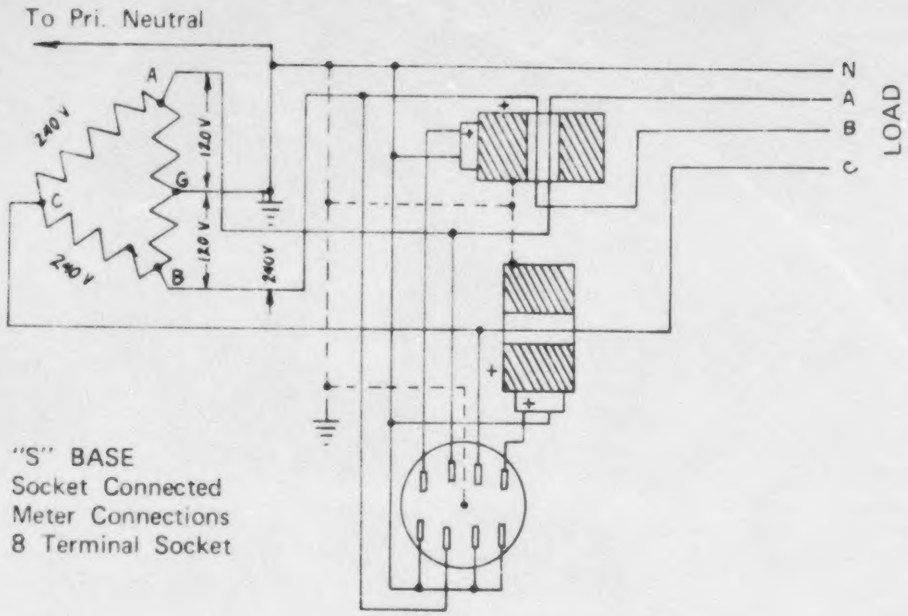
e. ____

11. Identify the following transformer-rated meter connections.



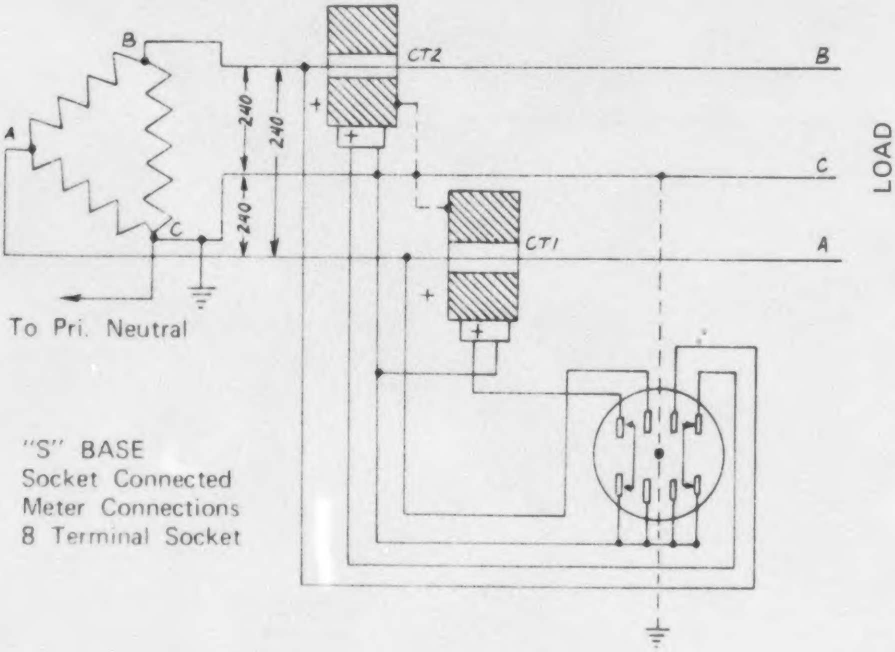
"S" BASE
Socket Connected
Meter Connections
5 Term. Socket

a. ____



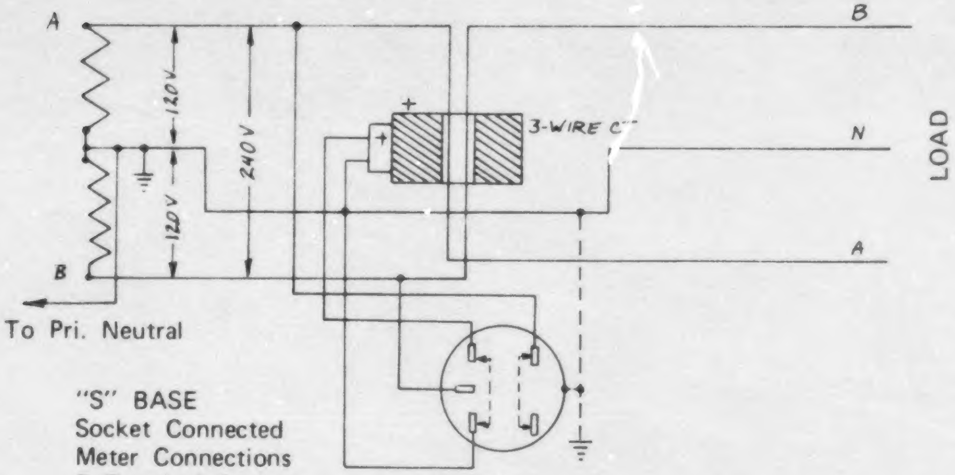
"S" BASE
Socket Connected
Meter Connections
8 Terminal Socket

b. ______________________________



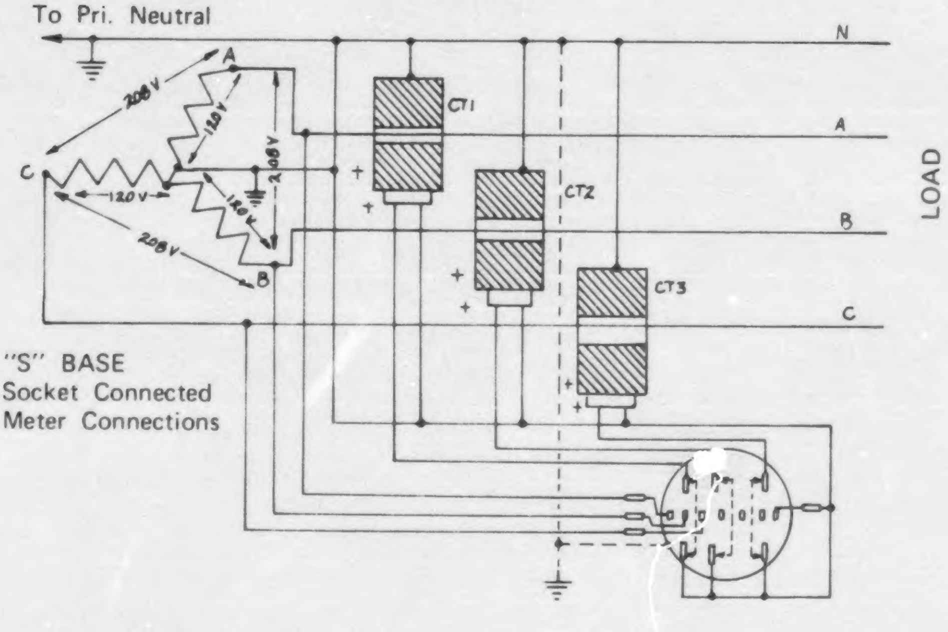
"S" BASE
Socket Connected
Meter Connections
8 Terminal Socket

c. ______________________________



"S" BASE
Socket Connected
Meter Connections
5 Terminal Socket

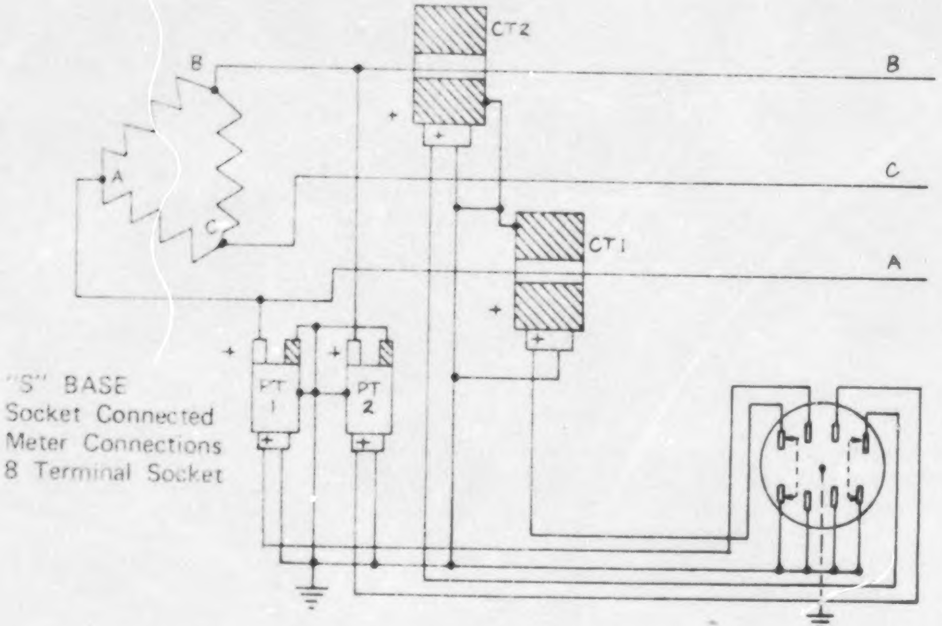
d. ______________________________



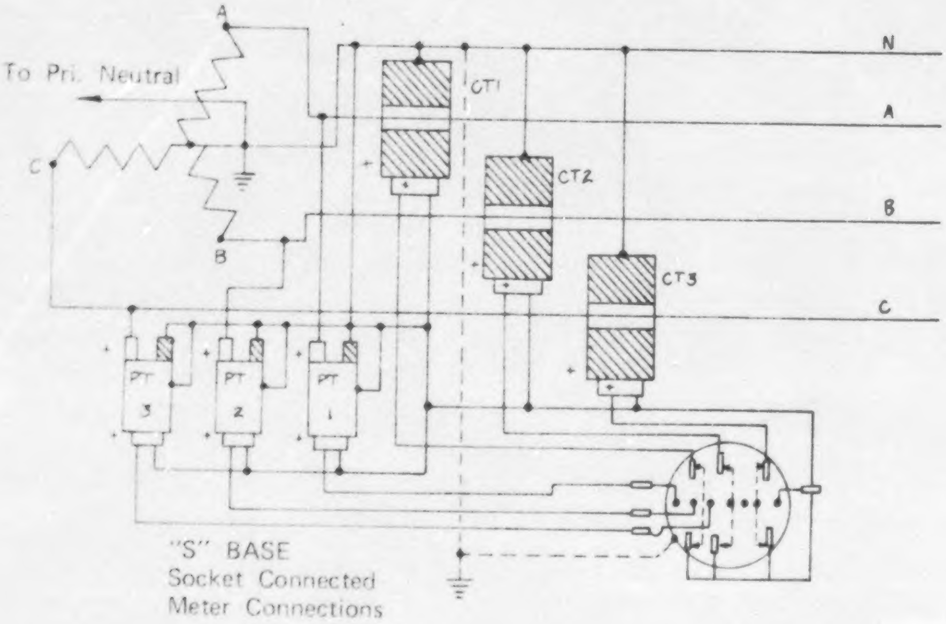
"S" BASE
Socket Connected
Meter Connections

e. ______________________________

12. Identify the following transformer-rated meter connections for 600 volts or above.



a. ______________________________



b. ______________________________

13. State the procedure for selecting the correct meter.

a. ____

b. ____

c. ____

d. ____

e. ____

14. List one way to determine meter voltage rating for both wye and delta connected services.

a. Wye-connected service--______________________________

____

b. Delta-connected service--______________________________

____

15. Match the types of services on the right to the correct uses.

_____a. Apartment complexes where both light and power loads may be heavy

_____b. Commercial and industrial areas where long circuit distances can be made with small conductor

_____c. Residences where three-phase power is needed for heating or air conditioning and industrial locations where small three-phase power is needed with large light loads

_____d. Most residences and small industrial locations

_____e. Billboards, shallow well pumps, and small dwellings

_____f. Power loads only for oil field and irrigation pumps

1. Three-wire three-phase 240 or 480 volt delta

2. Two-wire single-phase 120-volt service

3. Four-wire three-phase 120/240-volt delta

4. Three-wire single-phase 120/240 volt

5. Four-wire three-phase 277/480-volt wye

6. Four-wire three-phase 120/208-volt wye

16. List two types of meters which have multipliers.

a. ______________________________

b. ______________________________

17. Arrange in order the following procedure to determine a meter multiplier.

_____a. Record first gear reduction given by meter manufacturer

_____b. Multiply meter constant x register ratio x CT ratio x PT ratio x first gear reduction and divide product by 10,000

_____c. Record information from meter nameplate and meter register, K_h and R_r

_____d. Record ratios from current transformer and potential transformer

18. List four precautions to observe with metering.

a. ______________________________

____

b. ______________________________

____

c. ______________________________

____

d. ______________________________

____

19. Calculate meter multipliers.

(NOTE: If this activity has not been accomplished prior to the test, ask the instructor when it should be completed.)

METERS AND METER APPLICATION
UNIT I

ANSWERS TO TEST

1. Match the terms on the right to the correct definitions.

6 a. Rate at which an electrical circuit performs work

10 b. Power multiplied by time

3 c. Instrument which measures electrical energy

11 d. Gear train arranged to count the revolutions of a meter disc

9 e. One watt for one hour

7 f. One thousand watts for one hour

8 g. Stationary part of a meter which produces a magnetic flux that causes the meter disc to turn

4 h. Magnet or magnets which cause a retarding force on the meter disc

1 i. Power requirements (kW) over a period of time, usually 15 or 30 minutes

5 j. Device installed on a meter to prevent meter from running backwards when current flow through the meter is reversed

2 k. Meter register which registers energy even if meter is installed upside down

13 l. Small lamp that indicates the presence of voltage on the potential coil

12 m. Combination of single-phase meter stators in a single unit

1. Demand
2. Uni-directional register
3. Watt-hour meter
4. Damping system
5. Detent
6. Power
7. Kilowatt-hour
8. Stator
9. Watt-hour
10. Energy
11. Register
12. Polyphase meter
13. Potential indicator

20 n. Maximum current-carrying capability of a meter

17 o. Meter which carries entire load of current through its current coils

16 p. Meter that is used with current transformers to measure electrical energy

18 q. Watt-hours per revolution of the meter disc

19 r. Ratio of revolutions of the first register shaft to each revolution of the first pointer shaft

14 s. Ratio of revolutions of the meter disc to one revolution of the first register shaft

15 t. Relationship of current flow through a current transformer to the output current

14. First reduction
15. Current transformer ratio
16. Transformer-rated meter
17. Self-contained meter
18. K_h (meter constant)
19. R_r (register ratio)
20. Class

2. List two general types of meters.

   a. Self-contained

   b. Transformer-rated

3. List two types of meters by base construction.

   a. Socket base ("S" base)

   b. Bottom connected ("A" base)

4. List four classes of meters and the current-carrying capacity of each.

   a. Class 10, maximum current of 10 amperes

   b. Class 20, maximum current of 20 amperes

   c. Class 100, maximum current of 100 amperes

   d. Class 200, maximum current of 200 amperes

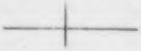
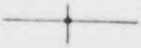
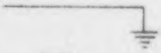
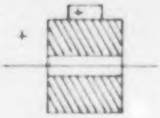
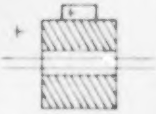
5. Match the meters on the right to the correct service type.

2	a. Three-phase four-wire delta	1.	Four-wire wye
1	b. Three-phase four-wire wye	2.	Four-wire delta
5	c. Single-phase two-wire	3.	Three-wire
4	d. Three-phase three-wire delta	4.	Three-wire delta
3	e. Single-phase three-wire	5.	Two-wire

6. Match the meter voltage ratings on the right to the correct types of service.

1	a. Single-phase two-wire	1.	Phase-to-ground
2	b. Single-phase three-wire	2.	Phase-to-phase
2	c. Three-phase three-wire delta		
2	d. Three-phase four-wire delta		
1	e. Three-phase four-wire wye		

7. Match the abbreviations and symbols on the right to the correct meanings.

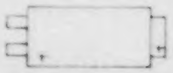
14	a. Potential transformer (symbol)	1.	
16	b. Ten pole test block	2.	
4	c. Potential transformer (abbreviation)	3.	
5	d. Current transformer	4.	**PT**
17	e. Delta connected	5.	**CT**
3	f. Ground	6.	**C_1**
12	g. Two-wire current transformer	7.	**P_1**
8	h. Ground connection	8.	**G**
2	i. Solid connection	9.	**N**
10	j. Self-contained	10.	**SC**
13	k. Three-wire current transformer	11.	**TR**
11	l. Transformer-rated	12.	
9	m. Neutral connection		
6	n. Current connection	13.	

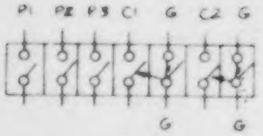
15 o. Seven pole test block

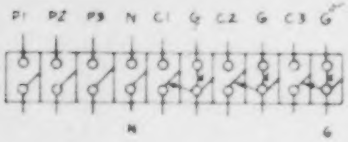
18 p. Wye connected

7 q. Potential connection

1 r. No connection

14. 

15. 

16. 

17. △

18. Y

8. List three uses of current transformer metering.

   a. Loads greater than 200 amperes

   b. Voltages of 480 or higher

   c. Locations where it would be impractical to install a large metering conductor

9. List two uses of self-contained meters.

   a. Loads of 200 amperes or less

   b. Voltages of 480 volts or less

10. Identify the following self-contained meter connections.

   a. Three-wire single-phase 120/240-volt service

   b. Four-wire three-phase 120/240-volt delta service

   c. Two-wire single-phase 120-volt service

   d. Three-wire three-phase 240-volt corner ground delta service

   e. Four-wire three-phase 120/208-volt wye service

11. Identify the following transformer-rated meter connections.

   a. Three-wire single-phase 240/480-volt service

   b. Four-wire three-phase 120/240-volt delta service

   c. Three-wire three-phase 240-volt delta service

   d. Three-wire single-phase 120/240-volt service

   e. Four-wire three-phase 120/208-volt wye service

12. Identify the following transformer-rated meter connections for 600 volts or above.

    a. Three-wire three-phase delta primary metering

    b. Four-wire three-phase wye primary metering

13. State the procedure for selecting a meter.

    a. Determine class of meter needed

    b. Determine voltage to be metered

    c. Determine phase of meter

    d. Determine service connection

    e. Determine wires of meter

14. List one method for determining meter voltage rating for both wye and delta connected services.

    a. Wye-connected service--Meter voltage will be line-to-ground voltage of service

    b. Delta-connected service--Meter voltage will be line-to-line voltage of service

15. Match the types of services on the right to the correct uses.

    __6__ a. Apartment complexes where both light and power loads may be heavy

    __5__ b. Commercial and industrial areas where long circuit distances can be made with small conductor

    __3__ c. Residences where three-phase power is needed for heating or air conditioning and industrial locations where small three-phase power is needed with large light loads

    __4__ d. Most residences and small industrial locations

    __2__ e. Billboards, shallow well pumps, and small dwellings

    __1__ f. Power loads only for oil field and irrigation pumps

    1. Three-wire three-phase 240 or 480 volt delta

    2. Two-wire single-phase 120-volt service

    3. Four-wire three-phase 120/240-volt delta

    4. Three-wire single-phase 120/240 volt

    5. Four-wire three-phase 277/480-volt wye

    6. Four-wire three-phase 120/208-volt wye

16. List two types of meters which have multipliers.

    a. All transformer-rated meters

    b. Some self-contained meters used on heavy loads

17. Arrange in order the following procedure to determine a meter multiplier.

    __3__ a. Record first gear reduction given by meter manufacturer

    __4__ b. Multiply meter constant x register ratio x CT ratio x PT ratio x first gear reduction and divide product by 10,000

    __1__ c. Record information from meter nameplate and meter register, K_h and R_r

    __2__ d. Record ratios from current transformer and potential transformer

18. List four precautions to observe with metering.

    a. Wear eye protection

    b. Wear your rubber gloves

    c. Do not remove a meter which is under load

    d. Short circuit the secondary side of current transformers before removing the meter

19. Calculate meter multipliers.

    (NOTE: This activity should be evaluated to the satisfaction of the instructor.)

SYSTEM KNOWLEDGE
(PHASE I)
UNIT II

UNIT OBJECTIVE

After completion of this unit, the student should be able to identify symbols used to represent overhead and underground lines and equipment and cultural features. The student should be able to use precautions with automated equipment. This knowledge will be evidenced by scoring 85 percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms used with system knowledge to the correct definitions.
2. Match various symbols used with overhead lines and equipment identification on system maps to the correct meanings.
3. Match various symbols used with underground lines and equipment identification on system maps to the correct meanings.
4. Identify various symbols used to locate cultural features on system maps.
5. List functions of automated equipment.
6. List precautions to observe with automated equipment.
7. Select from a list conditions associated with system terrain.

SYSTEM KNOWLEDGE
UNIT II

SUGGESTED ACTIVITIES

I. Suggested activities for the instructor:

   A. Provide student with objective sheet.

   B. Provide student with information and assignment sheets.

   C. Discuss unit and specific objectives.

   D. Discuss information and assignment sheets.

   E. Give test.

II. Unit references:

   A. Rural Electrification Administration. *Guide for Mapping and Location Numbering: Electric Distribution Systems.* REA Bulletin 40-4. Washington, D.C.: U.S. Department of Agriculture, 1974.

   B. Rural Electrification Administration. *Relieving Underground Corrosion on Multigrounded Rural Electric Lines.* REA Bulletin 161-23. Washington, D.C.: U.S. Department of Agriculture, 1963.

SYSTEM KNOWLEDGE
(PHASE I)
UNIT II

INFORMATION SHEET

I. Terms and definitions

A. Capacitor station--Location where one or more line voltage capacitors are installed

B. Automated equipment--Equipment that operates switches on capacitor, primary line, and other equipment without manual assistance

C. Fault current--Current that flows through a conductor when a fault occurs on a circuit line

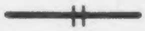
D. Galvanic action--Corrosion of anchor rods and other underground equipment caused by the flow of direct current to the neutral conductor and returning to earth through the underground equipment (Transparency 1)

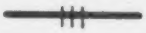
E. Feeder capacity--Ampacity of the conductors that distribute power from a substation

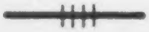
F. Multi-feed bank--Transformer bank which is energized by phases which have sources in different directions or possibly fed from different substations

G. Phase transposition--Location in the primary or transmission line where the phases change positions (Transparency 2)

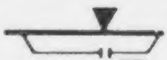
II. Symbols used on system maps for identification of overhead lines and equipment

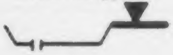
A. 1Ø primary line 

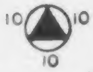
B. VØ primary line 

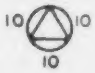
C. 3Ø primary line 

D. Transformer ▲

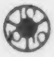
E. Primary, secondary underbuild 

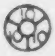
F. Secondary construction (bare) 

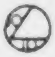
G. Transformer bank 3Ø△, rating KVA (system-owned) 

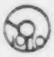
H. Transformer bank 3Ø△, rating KVA (consumer-owned) 

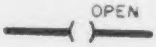
INFORMATION SHEET

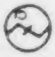
I. Transformer bank 3 ØY, rating KVA (system-owned) 

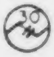
J. Transformer bank 3 ØY, rating KVA (consumer-owned) 

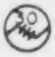
K. Transformer bank 3 Ø (open △) 

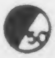
L. Transformer bank 3 Ø (open Y) 

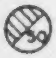
M. Normally open point 

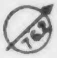
N. Fused cut-out, rating (single shot) 

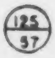
O. Fused cut-out, rating (2 shot) 

P. Fused cut-out, rating (3 shot) 

Q. Automatic circuit recloser, rating 

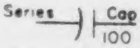
R. Automatic line sectionalizer, rating 

S. Voltage regulator, rating, KVA 

T. Minimum and maximum fault current 

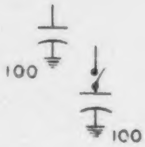
U. Air break switch (ganged) ABS

V. Disconnect switch DS

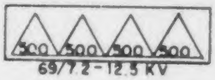
W. Capacitor bank-series, rating 

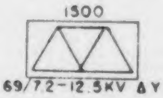
X. Capacitor bank-shunt, rating

Y. Capacitor bank-shunt, switched

(X and Y:) Indicate delta or wye when 3-phase bank 

Z. Metering point, capacity 500 KVA **M**

AA. Substation (indicate voltage and transformer size) 

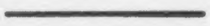
BB. Substation, 3-phase transformer (indicate voltage, transformer size, and winding) 

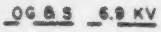
CC. Oil circuit breaker (station type) OCB

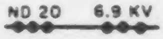
DD. Generating plant capacity 22000 KW **S**

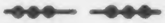
INFORMATION SHEET

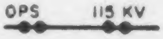
(NOTE: Use **S** for steam, **H** for hydro, **IC** for internal combustion, **N** for nuclear, and **GT** for gas turbine.)

EE. Distribution line (existing) 

FF. Other distribution line, voltage in kV, and name of utility 

GG. Transmission line, existing voltage, and system designation 

HH. Transmission line, proposed 

II. Transmission line, voltage, and name (other utilities) 

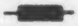
JJ. Consumer receiving electrical service

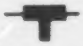
III. Symbols used on system maps for identification of underground lines and equipment

A. Transformer, underground

B. Pedestal, above ground or surface mounted

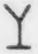
C. Pedestal, underground

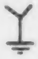
D. Splice (nonseparable) 

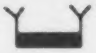
E. T-tap (nonseparable) 

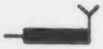
F. Elbow terminator

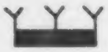
G. Bushing plug

H. Parking stand (insulated) 

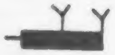
I. Parking stand (grounded) 

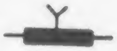
J. UM 3-02 (2 point load break connection) 

K. UM 3-11 (1 point load break, 1 point termination) 

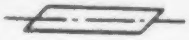
L. UM 3-03 (3 point load break) 

INFORMATION SHEET

M. UM 3-12 (2 point load break, 1 point termination) 

N. UM 3-21 (1 point load break, 2 point termination) 

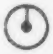
O. Fault indicator Ⓕ

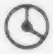
P. Cable in conduit 

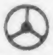
Q. Single-phase primary ——— – ———U——— – ———

R. V-phase primary ——— – ———U———2———

S. Three-phase primary ——— – ———U———3———

T. Single-phase primary riser 

U. V-phase primary riser 

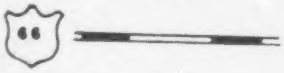
V. Three-phase primary riser 

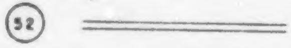
W. Secondary or service (3 wire) ----U--------

X. Secondary or service (4 wire) ----U----4----

Y. Transformer, surface mounted ☐

IV. Symbols used to identify cultural features on system maps

A. Federal highway 

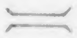
B. State road 

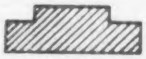
C. County road ═══════════

D. Unimproved road = = = = = = = = = = =

E. Railroad (with station) +————■————+

F. Telephone and telegraph line —T———T———T-

G. Bridge 

H. Cities and towns (within corporate limits) 

I. Towns and villages ○

INFORMATION SHEET

J. State capital ⊛

K. County seat ●

L. Houses and other buildings ▟ ■

M. School

V. Functions of automated equipment

A. Switches transmission line feed when fault occurs

B. Switches capacitors on and off the line

C. Starts and connects generator to line when outage occurs

D. Connects distribution circuits together during peak loads

VI. Precautions to observe with automated equipment

A. Know the locations of all automated equipment on the system

B. Know the functions of all automated equipment on the system

C. Be able to override or disconnect automated equipment when necessary

VII. Conditions associated with system terrain

A. Road conditions during wet weather

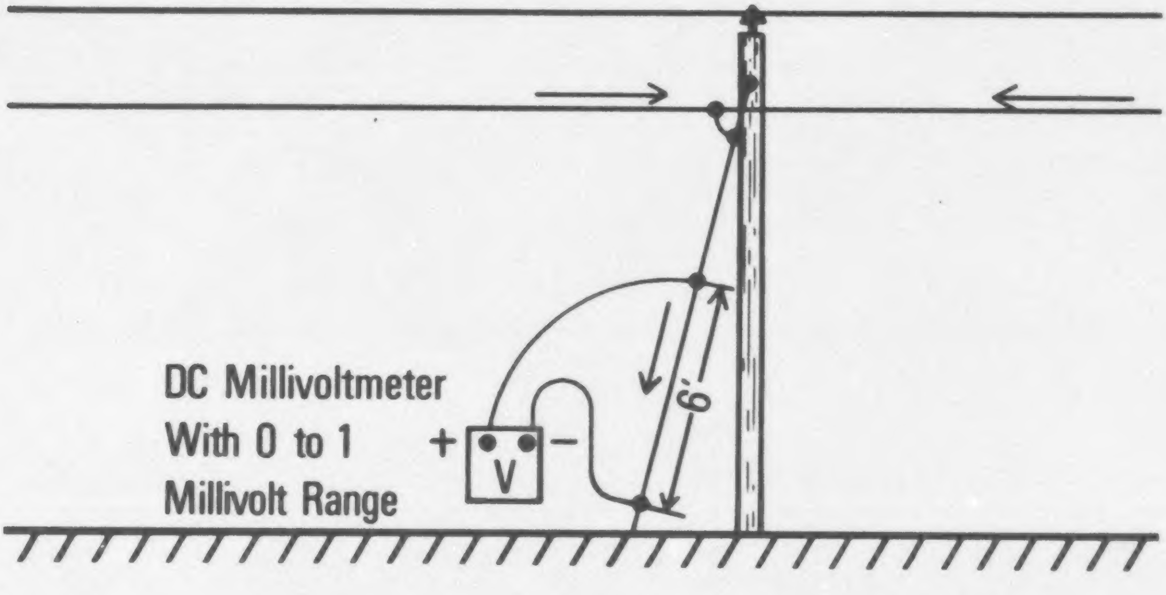
B. Soil conditions throughout the system

C. Areas where blasting may be required to construct lines

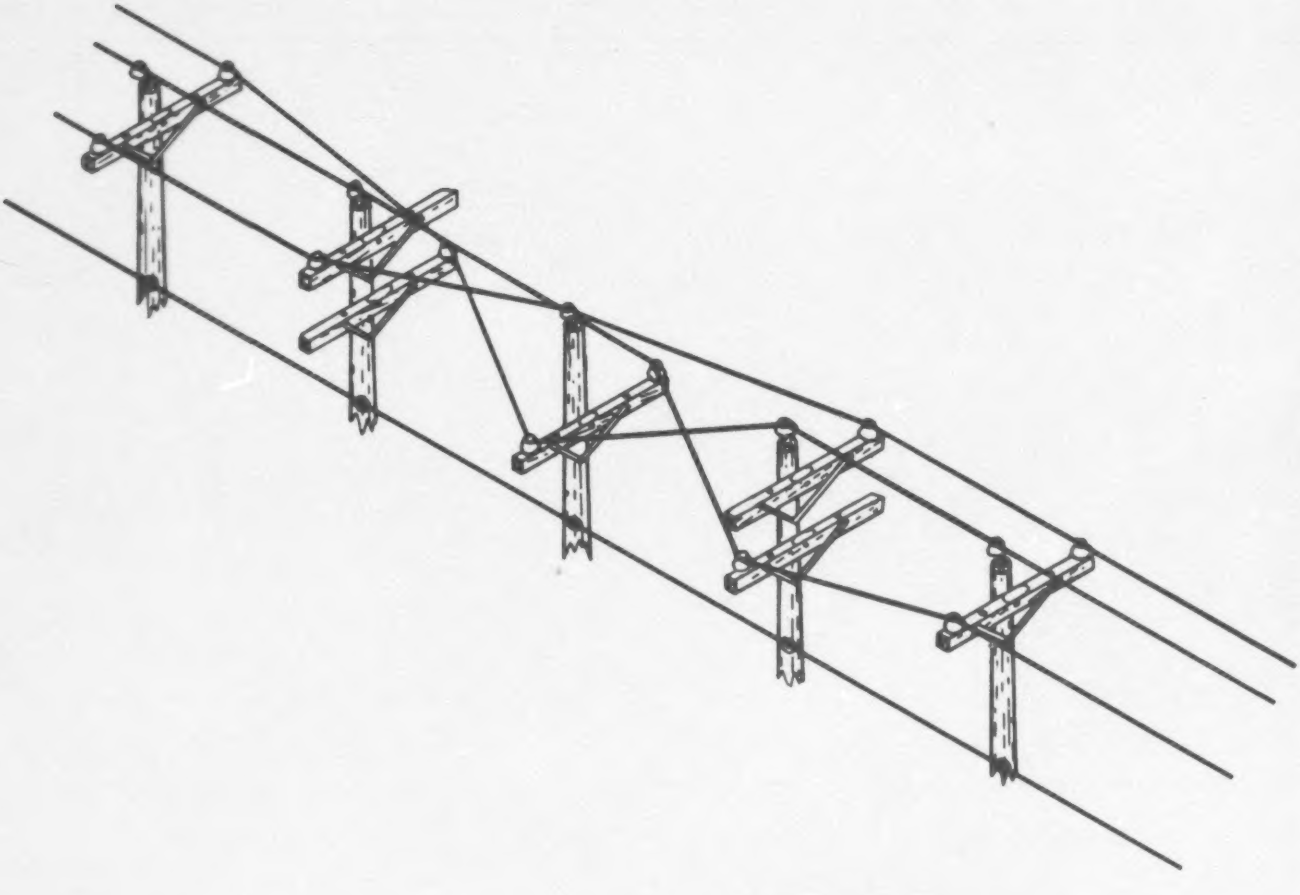
D. Areas of limited access

E. Areas where special equipment may be required to obtain access

Determination Of Galvanic Current From Voltage Drop Along A Guy



Transposition

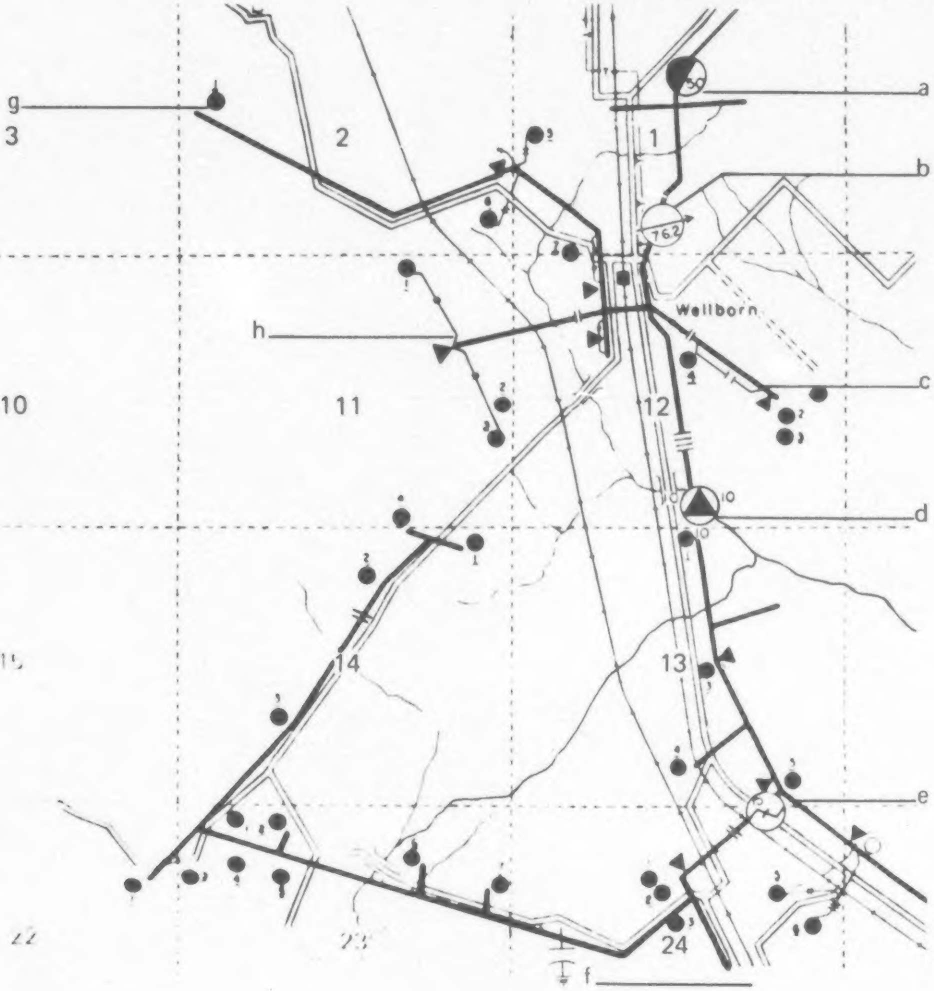


SYSTEM KNOWLEDGE
(PHASE I)
UNIT II

ASSIGNMENT SHEET #1--IDENTIFY SYMBOLS ON A SYSTEM MAP

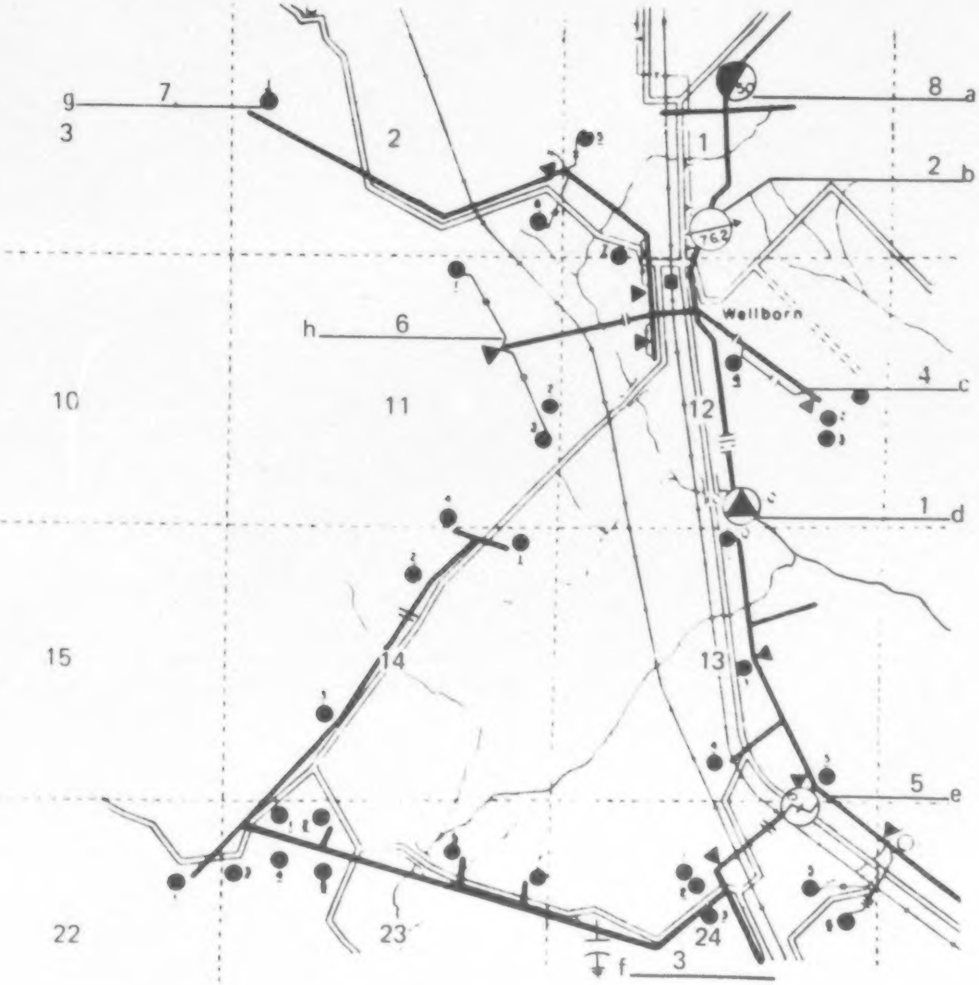
Identify the symbols on the map by placing the corresponding number in the blank.

1. Three-phase delta bank
2. Voltage regulator
3. Capacitor
4. Primary, secondary underbuild
5. Fuse cut-out
6. Secondary construction
7. Consumer receiving electrical service
8. Automatic circuit recloser



SYSTEM KNOWLEDGE
(PHASE I)
UNIT II

ANSWERS TO ASSIGNMENT SHEET



SYSTEM KNOWLEDGE
(PHASE I)
UNIT II

TEST

NAME ______________________________ SCORE ______________

1. Match the terms on the right to the correct definitions.

_____a. Location where one or more line voltage capacitors are installed

_____b. Equipment that operates switches on capacitor, primary line, and other equipment without manual assistance

_____c. Current that flows through a conductor when a fault occurs on a circuit line

_____d. Corrosion of anchor rods and other underground equipment caused by the flow of direct current to the neutral conductor and returning to earth through the underground equipment

_____e. Ampacity of the conductors that distribute power from a substation

_____f. Transformer bank which is energized by phases which have sources in different directions or possibly fed from different substations

_____g. Location in the primary or transmission line where the phases change positions

1. Fault current
2. Feeder capacity
3. Capacitor station
4. Multi-feed bank
5. Phase transposition
6. Automated equipment
7. Galvanic action

2. Match the overhead electrical symbols on the right to the correct meanings. (Symbols and meanings are continued on the following pages. Answers to "a" through "m" are on this page.)

_____a. Consumer receiving electrical service

_____b. 1 Ø primary line

_____c. V Ø primary line

_____d. 3 Ø primary line

_____e. Transformer

_____f. Primary, secondary underbuild

_____g. Secondary construction (bare)

_____h. Transformer bank 3Ø△ rating KVA (system-owned)

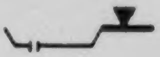
_____i. Transformer bank 3Ø△ rating KVA (consumer-owned)

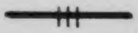
_____j. Transformer bank 3ØY, rating KVA (system-owned)

_____k. Transformer bank 3ØY, rating KVA (consumer-owned)

_____l. Transformer bank 3 Ø (open△)

_____m. Transformer bank 3 Ø (open Y)

1. 

2. 

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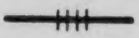
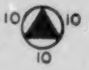
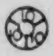
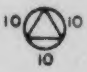
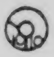
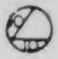
4. 

5. 

6. 

7. 

8. 

9. 

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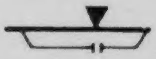
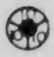
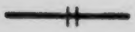
11. 

12. 

13. 

_____n. Normally open point

_____o. Fused cut-out, rating (single shot)

_____p. Fused cut-out, rating (2 shot)

_____q. Fused cut-out, rating (3 shot)

_____r. Automatic circuit recloser, rating

_____s. Automatic line sectionalizer, rating

_____t. Voltage regulator, rating, KVA

_____u. Minimum and maximum fault current

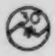
_____v. Air break switch (ganged)

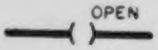
_____w. Disconnect switch

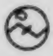
_____x. Capacitor bank-series, rating

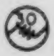
_____y. Capacitor bank-shunt, rating

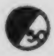
_____z. Capacitor bank-shunt, switched

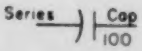
14. 

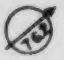
15. 

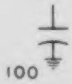
16. 

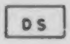
17. 

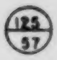
18. 

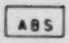
19. 

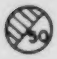
20. 

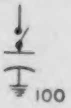
21. 

22. 

23. 

24. 

25. 

26. 

____aa. Metering point, capacity

____bb. Substation (indicate voltage and transformer size)

____cc. Substation, 3-phase transformer (indicate voltage, transformer size, and winding)

____dd. Oil circuit breaker (station type)

____ee. Generating plant, capacity

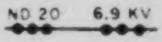
____ff. Distribution line (existing)

____gg. Other distribution line, voltage in kV, and name of utility

____hh. Transmission line, existing, voltage, and system designation

____ii. Transmission line, proposed

____jj. Transmission line, voltage, and name (other utilities)

27.


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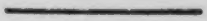

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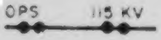

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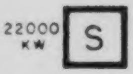

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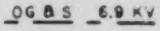

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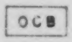

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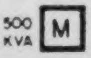

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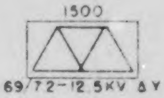

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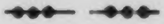

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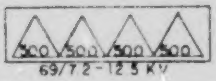


3. Match the underground electrical symbols on the right to the correct meanings. (Symbols and meanings are continued on the following page. Answers for "a" through "m" are on this page.)

_____a. Transformer, underground

_____b. Pedestal, above ground or surface mounted

_____c. Pedestal, underground

_____d. Splice (nonseparable)

_____e. T-tap (nonseparable)

_____f. Elbow terminator

_____g. Bushing plug

_____h. Parking stand (insulated)

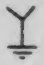
_____i. Parking stand (grounded)

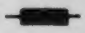
_____j. UM 3-02 (2 point load break connection)

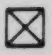
_____k. UM 3-11 (1 point load break, 1 point termination

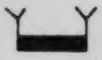
_____l. UM 3-03 (3 point load break)

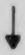
_____m. UM 3-12 (2 point load break, 1 point termination)

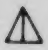
1. 

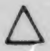
2. 

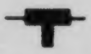
3. 

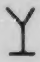
4. 

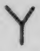
5. 

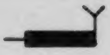
6. 

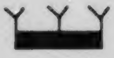
7. 

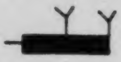
8. 

9. 

10. 

11. 

12. 

13. 

_____n. UM 3-21 (1 point load break, 2 point termination)

_____o. Fault indicator

_____p. Cable in conduit

_____q. Single-phase primary

_____r. V-phase primary

_____s. Three-phase primary

_____t. Single-phase primary riser

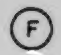
_____u. V-phase primary riser

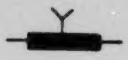
_____v. Three-phase primary riser

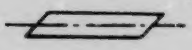
_____w. Secondary or service (3 wire)

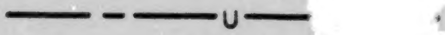
_____x. Secondary or service (4 wire)

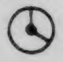
_____y. Transformer, surface mounted

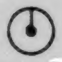
14. 

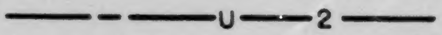
15. 

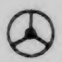
16. 

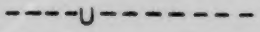
17. 

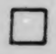
18. 

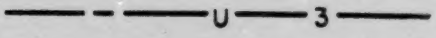
19. 

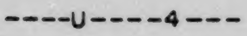
20. 

21. 

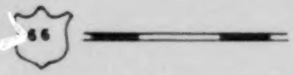
22. 

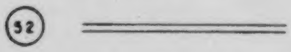
23. 

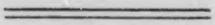
24. 

25. 

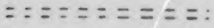
4. Identify the following cultural feature symbols.

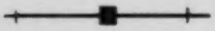


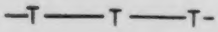




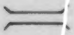
a. ____________ b. ____________ c. ____________

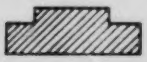




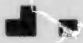


d. ____________ e. ____________ f. ____________





g. ____________ h. ____________ i. ____________



j. ____________ k. ____________ l. ____________

m. ____________

5. List three functions of automated equipment.

a. ____

____

b. ____

____

c. ____

____

6. List three precautions to observe with automated equipment.

a. ____

____

b. ____

____

c. ____

____

7. Select from the following list the conditions associated with system terrain by placing an "X" in the blanks.

______a. Areas of limited access

______b. Road conditions during wet weather

______c. Areas where blasting may be required to construct lines

______d. Areas of rapid brush growth

______e. Soil conditions throughout the system

______f. Areas where special equipment may be required to obtain access

SYSTEM KNOWLEDGE
(PHASE I)
UNIT II

ANSWERS TO TEST

1. Match the terms on the right to the correct definitions.

__3__ a. Location where one or more line voltage capacitors are installed

__6__ b. Equipment that operates switches on capacitor, primary line, and other equipment without manual assistance

__1__ c. Current that flows through a conductor when a fault occurs on a circuit line

__7__ d. Corrosion of anchor rods and other underground equipment caused by the flow of direct current to the neutral conductor and returning to earth through the underground equipment

__2__ e. Ampacity of the conductors that distribute power from a substation

__4__ f. Transformer bank which is energized by phases which have sources in different directions or possibly fed from different substations

__5__ g. Location in the primary or transmission line where the phases change positions

1. Fault current
2. Feeder capacity
3. Capacitor station
4. Multi-feed bank
5. Phase transposition
6. Automated equipment
7. Galvanic action

2. Match the overhead electrical symbols on the right to the correct meanings. (Symbols and meanings are continued on the following pages. Answers to "a" through "m" are on this page.)

10 a. Consumer receiving electrical service

13 b. 1 Ø primary line

2 c. V Ø primary line

4 d. 3 Ø primary line

3 e. Transformer

11 f. Primary, secondary underbuild

1 g. Secondary construction (bare)

5 h. Transformer bank 3Ø△ rating KVA (system-owned)

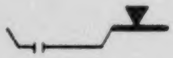
7 i. Transformer bank 3Ø△ rating KVA (consumer-owned)

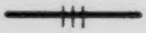
12 j. Transformer bank 3ØY, rating KVA (system-owned)

6 k. Transformer bank 3ØY, rating KVA (consumer-owned)

9 l. Transformer bank 3 Ø (open△)

8 m. Transformer bank 3 Ø (open Y)

1. 

2. 

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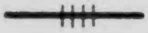
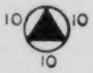
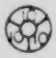
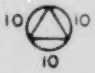
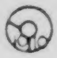
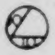
4. 

5. 

6. 

7. 

8. 

9. 

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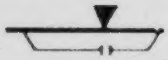
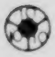
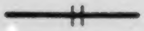
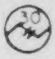
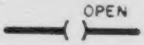
11. 

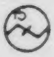
12. 

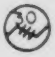
13. 

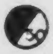
15 n. Normally open point
16 o. Fused cut-out, rating (single shot)
14 p. Fused cut-out, rating (2 shot)
17 q. Fused cut-out, rating (3 shot)
18 r. Automatic circuit recloser, rating
25 s. Automatic line sectionalizer, rating
20 t. Voltage regulator, rating, KVA
23 u. Minimum and maximum fault current
24 v. Air break switch (ganged)
22 w. Disconnect switch
19 x. Capacitor bank-series, rating
21 y. Capacitor bank-shunt, rating
26 z. Capacitor bank-shunt, switched

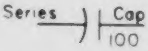
14. 

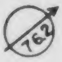
15. 

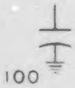
16. 

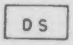
17. 

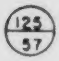
18. 

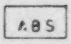
19. 

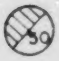
20. 

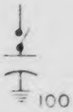
21. 

22. 

23. 

24. 

25. 

26. 

33 aa. Metering point, capacity

36 bb. Substation (indicate voltage and transformer size)

34 cc. Substation, 3-phase transformer (indicate voltage, transformer size, and winding)

32 dd. Oil circuit breaker (station type)

30 ee. Generating plant, capacity

28 ff. Distribution line (existing)

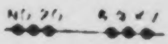
31 gg. Other distribution line, voltage in kV, and name of utility

27 hh. Transmission line, existing, voltage, and system designation

35 ii. Transmission line, proposed

29 jj. Transmission line, voltage, and name (other utilities)

27.



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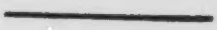

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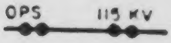

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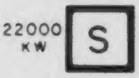

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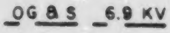

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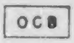

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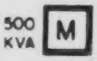

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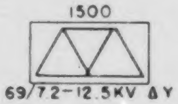

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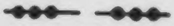

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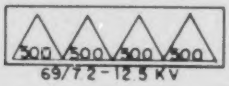


3. Match the underground electrical symbols on the right to the correct meanings. (Symbols and meanings are continued on the following page. Answers for "a" through "m" are on this page.)

__3__ a. Transformer, underground

__7__ b. Pedestal, above ground or surface mounted

__6__ c. Pedestal, underground

__2__ d. Splice (nonseparable)

__8__ e. T-tap (nonseparable)

__5__ f. Elbow terminator

__10__ g. Bushing plug

__9__ h. Parking stand (insulated)

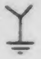
__1__ i. Parking stand (grounded)

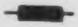
__4__ j. UM 3-02 (2 point load break connection)

__11__ k. UM 3-11 (1 point load break, 1 point termination

__12__ l. UM 3-03 (3 point load break)

__13__ m. UM 3-12 (2 point load break, 1 point termination)

1. 

2. 

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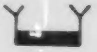
4. 

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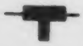
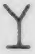
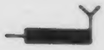
6.

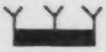
7.

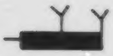
8. 

9. 

10.

11. 

12. 

13. 

15 n. UM 3-21 (1 point load break, 2 point termination)

14 o. Fault indicator

16 p. Cable in conduit

17 q. Single-phase primary

20 r. V-phase primary

24 s. Three-phase primary

19 t. Single-phase primary riser

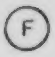
18 u. V-phase primary riser

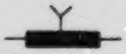
21 v. Three-phase primary riser

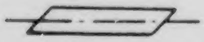
22 w. Secondary or service (3 wire)

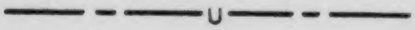
25 x. Secondary or service (4 wire)

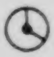
23 y. Transformer, surface mounted

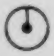
14. 

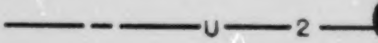
15. 

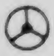
16. 

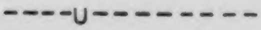
17. 

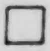
18. 

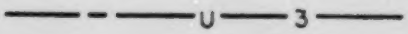
19. 

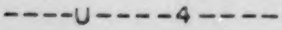
20. 

21. 

22. 

23. 

24. 

25. 

4. Identify the following cultural feature symbols.

   a. Federal highway

   b. State road

   c. County road

   d. Unimproved road

   e. Railroad (with station)

   f. Telephone and telegraph line

   g. Bridge

   h. Cities and towns (within corporate limits)

   i. Towns and villages

   j. State capital

   k. County seat

   l. Houses and other buildings

   m. School

5. List three functions of automated equipment.

   (NOTE: Any three of the following are acceptable.)

   a. Switches transmission line feed when a fault occurs

   b. Switches capacitors on and off the line

   c. Starts and connects generator to line when outage occurs

   d. Connects distribution circuits together during peak loads

6. List three precautions to observe with automated equipment.

   a. Know the locations of all automated equipment on the system

   b. Know the functions of all automated equipment on the system

   c. Be able to override or disconnect automated equipment when necessary

7. Select from the following list the conditions associated with system terrain by placing an "X" in the blanks.

___X___ a. Areas of limited access

___X___ b.. Road conditions during wet weather

___X___ c. Areas where blasting may be required to construct lines

______ d. Areas of rapid brush growth

___X___ e. Soil conditions throughout the system

___X___ f. Areas where special equipment may be required to obtain access

TRANSFORMER CONNECTIONS AND BANKING
UNIT III

UNIT OBJECTIVE

After completion of this unit, the student should be able to select and connect transformers in two- and three-transformer banks. The student should be able to connect transformer windings in series and parallel and be able to locate a faulted transformer in a bank. This knowledge will be evidenced through demonstration and by scoring 85 percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms commonly used with transformer connections and banking to the correct definitions.
2. Match symbols used with transformer voltage rating and connection diagrams to the correct meanings.
3. Identify secondary coil connections.
4. Identify various single transformer connections for three-wire service.
5. Identify various two-transformer banks.
6. Identify various three-transformer banks.
7. List precautions to observe when selecting transformers to be banked or paralleled.
8. Identify various secondary connections on a four bushing transformer.
9. State the correct method of connecting wye and delta transformers to a primary line.
10. Arrange in order steps to find a faulted transformer in a bank.
11. State precautions to observe with transformer banks.
12. Connect transformer secondary coils in series and parallel.
13. Connect a wye-delta bank for three-phase four-wire 120/240-volt service.

14. Connect a wye-delta bank for three-phase three-wire 240-volt service.

15. Connect a wye-wye bank for three-phase four-wire 120/208-volt service.

16. Connect an open-wye open-delta bank for three-phase four-wire 120/240-volt service.

17. Connect an open-wye open-delta bank for three-phase three-wire 240-volt service.

18. Connect an open-delta open-delta bank for three-phase four-wire 120/240-volt service.

19. Connect two single-bushing transformers in parallel.

TRANSFORMER CONNECTIONS AND BANKING
UNIT III

SUGGESTED ACTIVITIES

I. Suggested activities for the instructor:

   A. Provide student with objective sheet.

   B. Provide student with information and assignment sheets.

   C. Make transparencies.

   D. Discuss unit and specific objectives.

   E. Discuss information and assignment sheets.

   F. Give test.

II. Unit references:

   A. *Distribution Transformer Manual.* GET-2485K. Hickory, North Carolina: General Electric Co., 1975.

   B. Kurtz, Edwin B., and Shoemaker, Thomas M. *The Lineman's and Cableman's Handbook.* 5th ed. New York: McGraw-Hill Book Company, 1976.

   C. Rural Electrification Administration. *Application Guide for Transformers.* REA Bulletin 161-22. Washington, D.C.: U.S. Department of Agriculture, 1961.

TRANSFORMER CONNECTIONS AND BANKING
UNIT III

INFORMATION SHEET

I. Terms and definitions

   A. Polarity--Designation of relative current flow and purely a function of how the leads are brought out of a transformer (Transparency 1)

   B. Subtractive polarity--Instantaneous voltages of the two transformer windings subtract from each other when connected in sequence

   C. Additive polarity--Instantaneous voltages of the two transformer windings add to each other when connected in sequence

   D. Delta--Symbol (Δ) used to identify the diagrams that describe a system using three transformers whose secondary windings are connected in series

   E. Star or wye--Symbol (Y) used to identify diagrams that describe a system using three transformers whose secondary windings are paralleled

   F. Open delta--Symbol (∧) used to identify a connection that uses two transformers for a three-phase service

   G. Wild leg--Term used to identify the high voltage leg of a four-wire delta-connected secondary

   H. Impedance--Combined effect of resistance and inductive reactance

II. Transformer connection diagram and voltage rating symbols

   A. ____--Separates voltage rating of high side and low side windings

   B. /--Separates tap voltage and voltage rating of one winding

   C. X--Separates windings that may be connected in parallel or series

   D. Y--Indicates a winding suitable for phase-to-ground connection

   E. H_1, H_2, and H_3--Indicate high voltage connections

   F. X_1, X_2, X_3, and X_4--Indicate low voltage connections

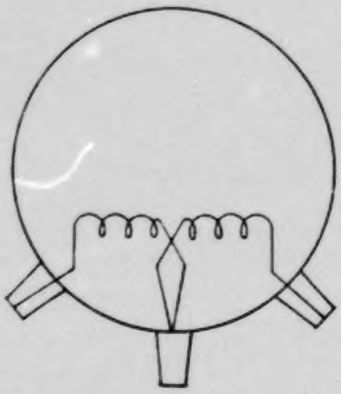
   G. H_0--Indicates the primary ground or common connection

   H. X_0--Indicates the secondary ground connection

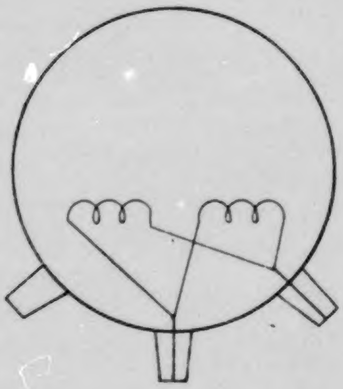
INFORMATION SHEET

III. Secondary coil connections

A. Series connected for 120/240 volt three-wire service



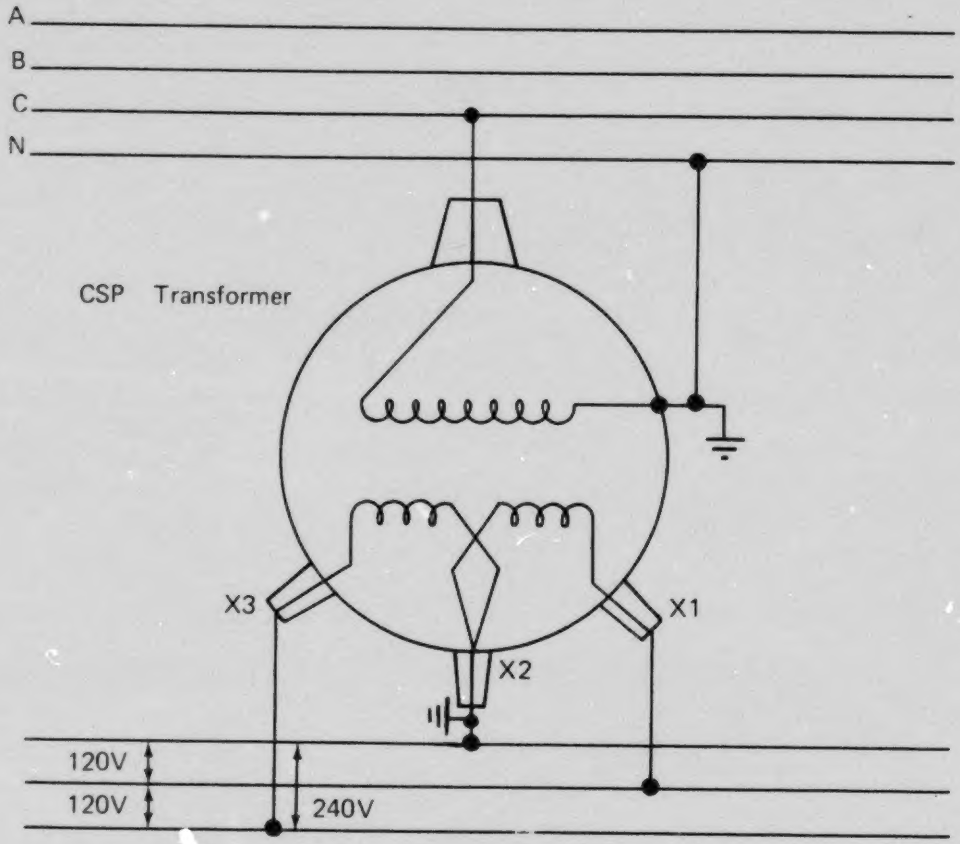
B. Parallel connected for 120 volt two-wire service



INFORMATION SHEET

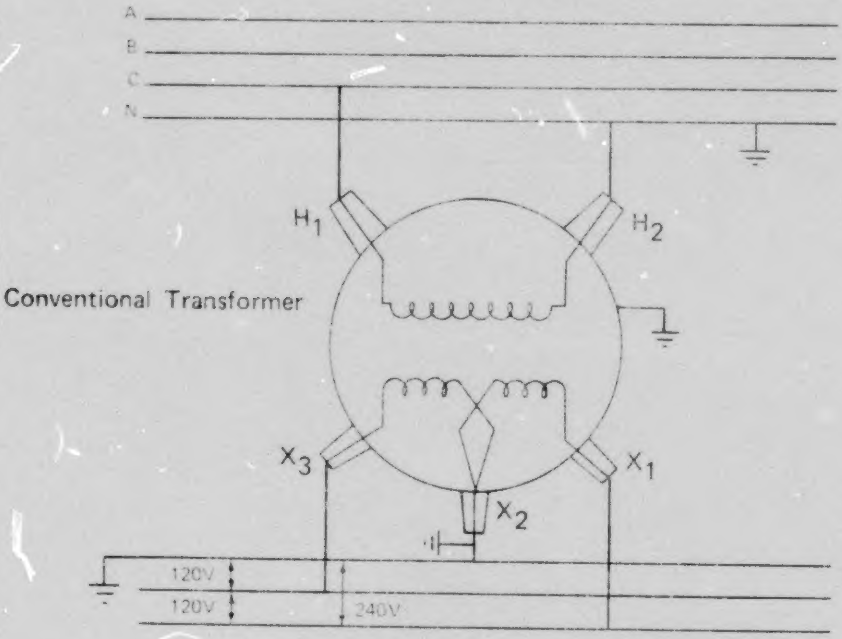
IV. Single transformer connections for three-wire service

A. Single-bushing primary connection (three-wire 120/240 volt secondary)



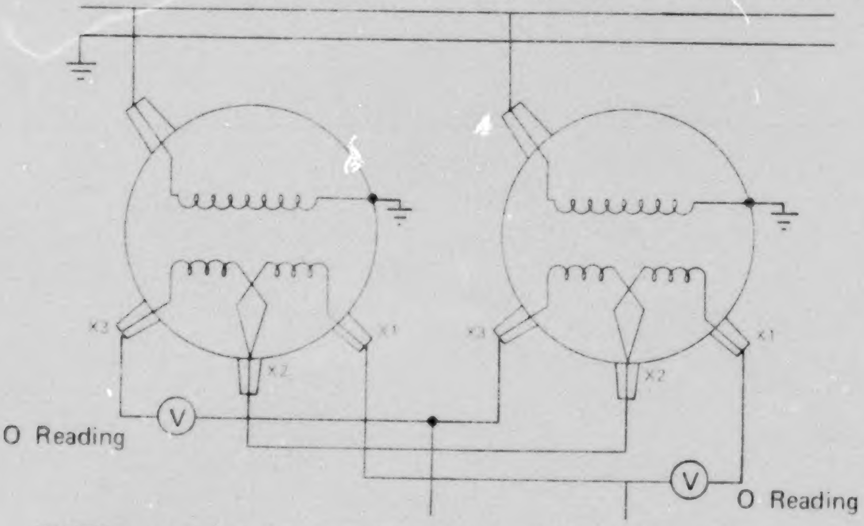
INFORMATION SHEET

B. Two-bushing primary connection (three-wire 120/240-volt service)



(NOTE: The secondary coils of both the single- and two-bushing transformers may be connected in parallel for a two-wire service. This may be used for 120/240, 240/480, 240, or 480 volt secondary.)

C. Two single-bushing transformers paralleled (three-wire 120/240-volt service)

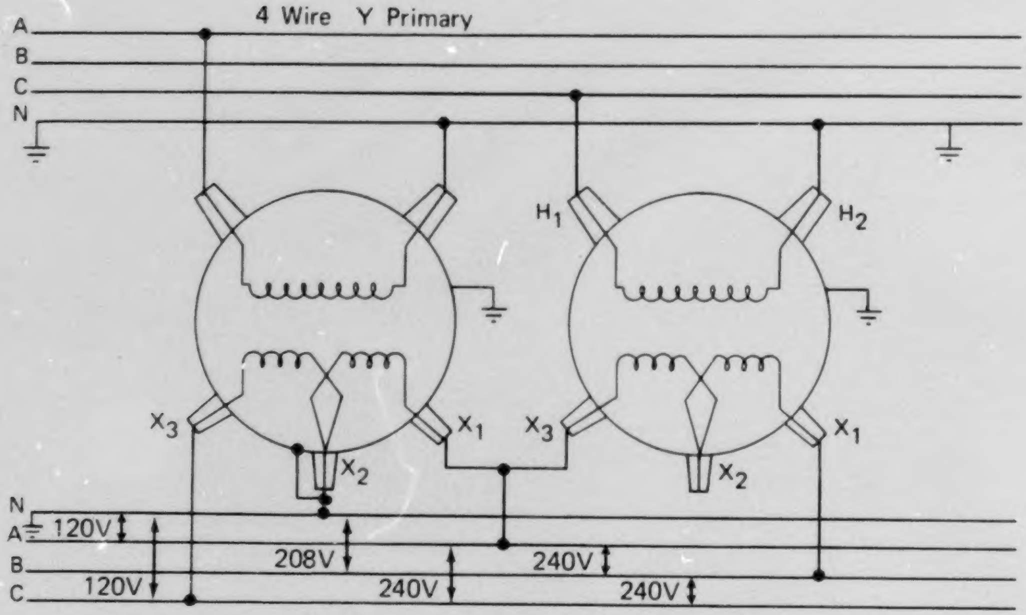


(NOTE: A zero voltage reading will be indicated by checking between the X3 and X1 terminals of each transformer if they have been matched for paralleling.)

INFORMATION SHEET

V. Two-transformer banks

A. Open-wye open-delta for three-phase four-wire 120/240 volt service

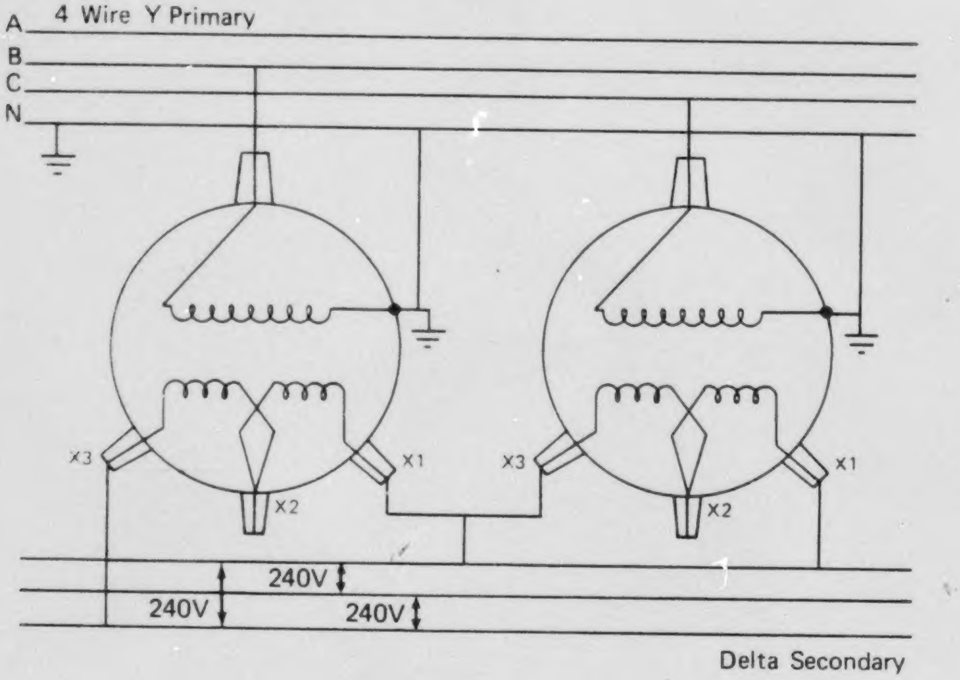


(CAUTION: Only one X_2 bushing may be grounded.)

(NOTE: The efficiency of this bank is 86.6% of the rating of the two transformers and is not recommended for large three-phase loads. If both transformers were 50 KVA rated, the actual capacity of the bank would be 86.6 KVA rather than 100 KVA.)

INFORMATION SHEET

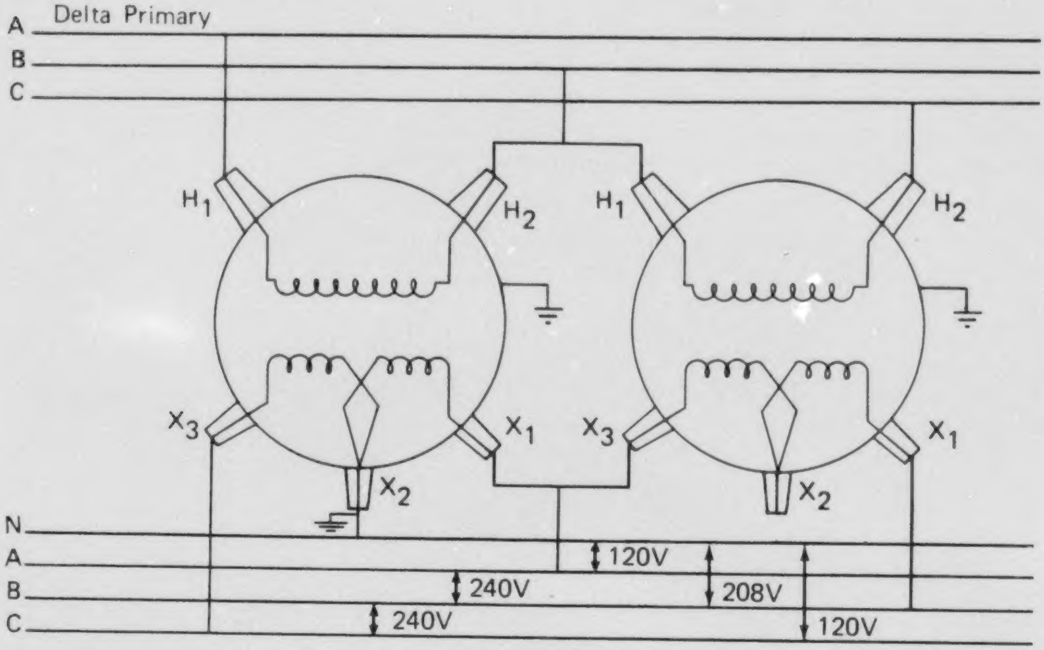
B. Open-wye open-delta for three-phase three-wire 240 volt service



(NOTE: If a ground is required, either X_1 or X_2 may be grounded. A ground on X_2 would make this a four-wire 120/240 volt secondary. A ground on X_1 would make this bank a three-wire corner grounded delta secondary. CSP or conventional transformers may be used with this bank.)

INFORMATION SHEET

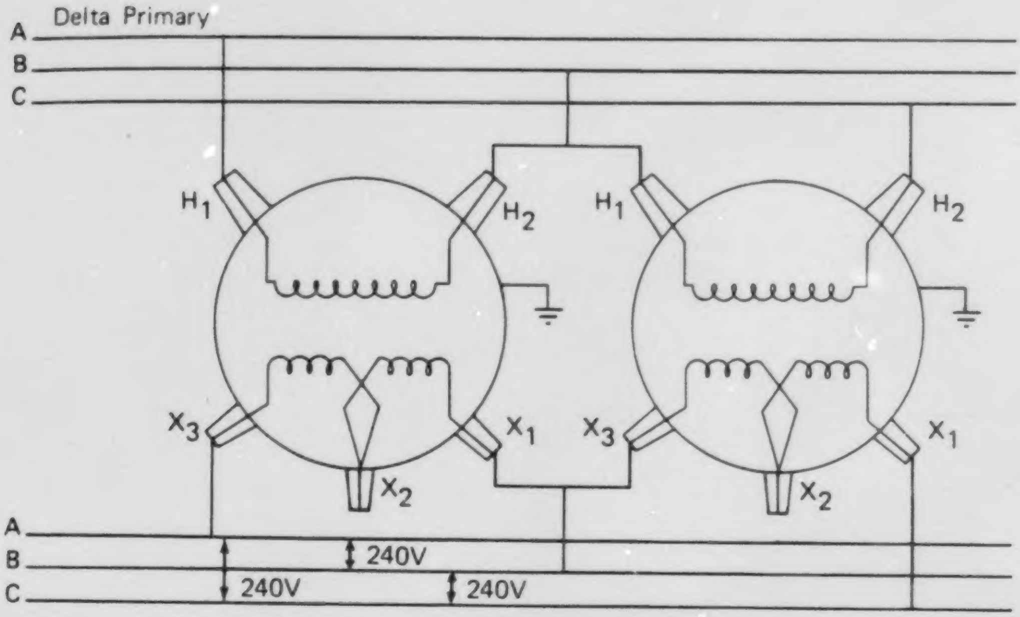
C. Open-delta open-delta for three-phase four-wire 120/240 volt service



(NOTE: This bank is similar to the open-wye open-delta except the primary coils are connected phase-to-phase rather than phase-to-ground in the open-wye bank.)

INFORMATION SHEET

D. Open-delta open-delta for three-phase three-wire 240 volt service

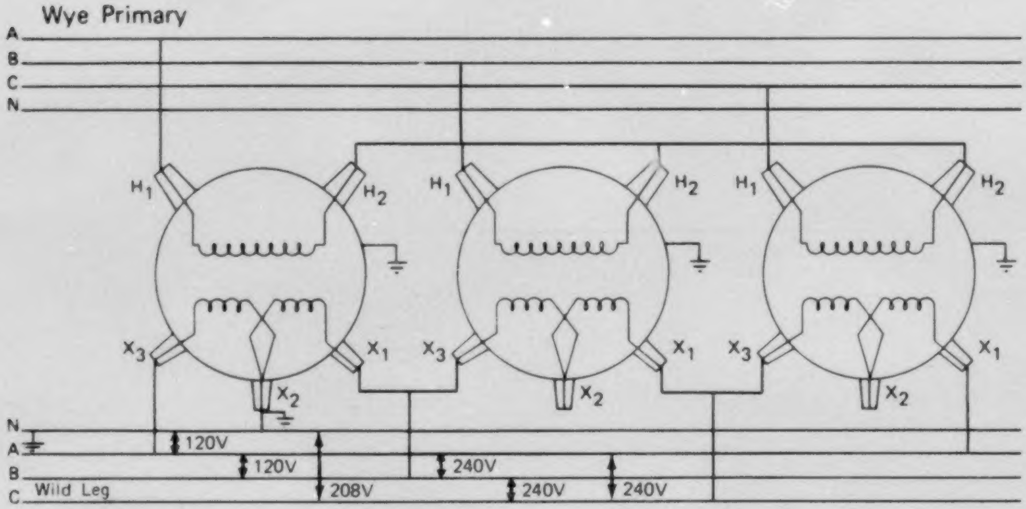


(NOTE: This bank is suitable for large single-phase power loads with small three-phase loads.)

INFORMATION SHEET

VI. Three-transformer banks

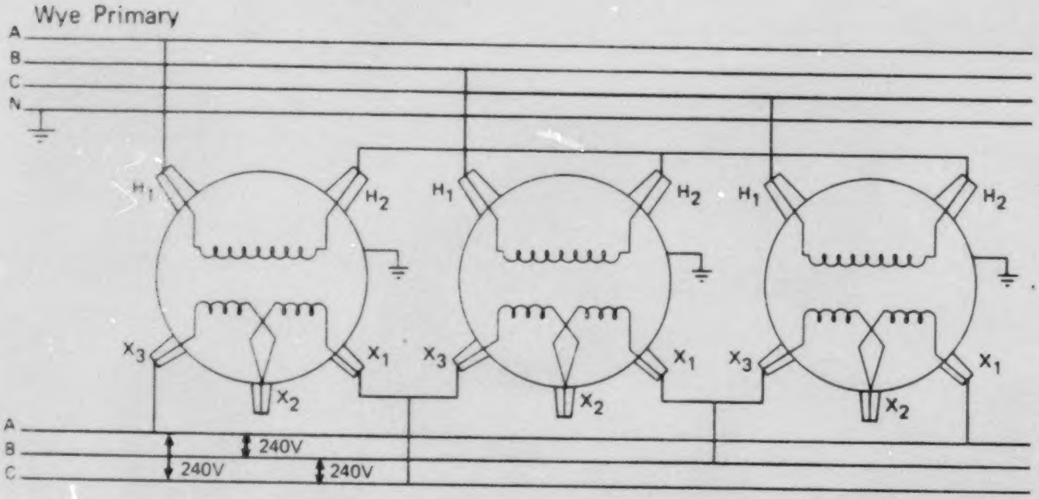
A. Wye-delta for three-phase four-wire 120/240 volt service



(NOTE: The transformer with the mid tap ground carries two-thirds of the 120/240-volt single-phase load and one-third of the 240-volt three-phase load. The other two transformers carry one-third of the 120/240 and 240-volt loads.)

INFORMATION SHEET

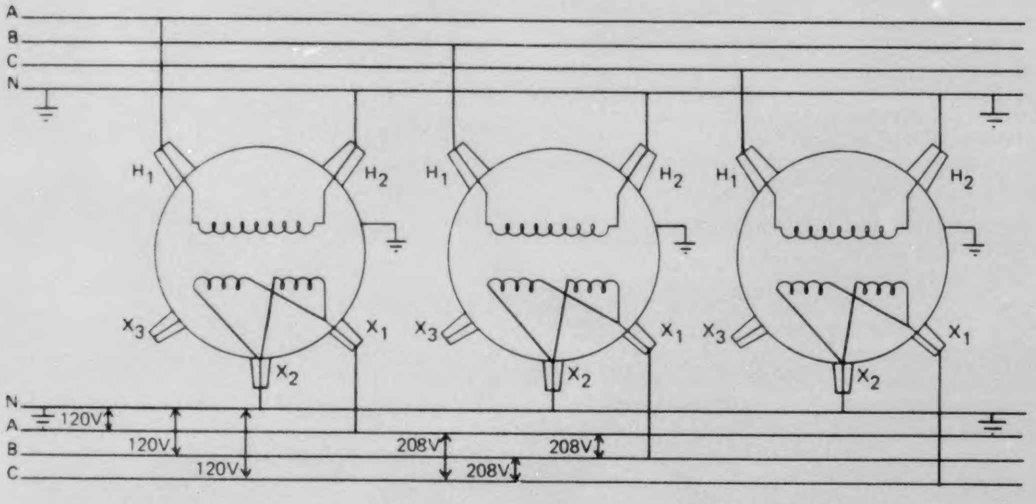
B. Wye-delta for three-phase three-wire 240 volt service



(NOTE: The H_2 bushings of this bank are not grounded. The likelihood of burnout of this bank is reduced because the failure of any one of the transformers will render the bank inoperative.)

INFORMATION SHEET

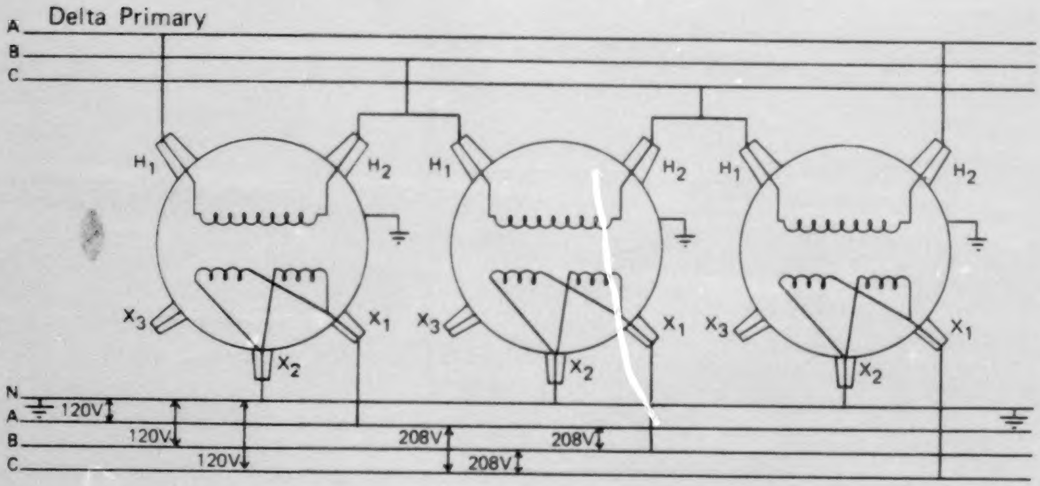
C. Wye-wye for three-phase four-wire 120/208 volt service



(NOTE: If the H_2 bushings are not bonded solidly to the system neutral, excessive voltage may occur on the secondary side. This bank may also be used for 277/480 service. Single bushing CSP transformers may be used with this bank.)

INFORMATION SHEET

D. Delta-wye for three-phase four-wire 120/208 volt service



(NOTE: The safe rating of a three-transformer bank is three times the KVA rating of the smallest transformer in the bank.)

VII. Precautions to observe when selecting transformers to be banked or paralleled

A. Check the polarity marked on nameplate

B. Check primary voltage rating

C. Check secondary voltage rating

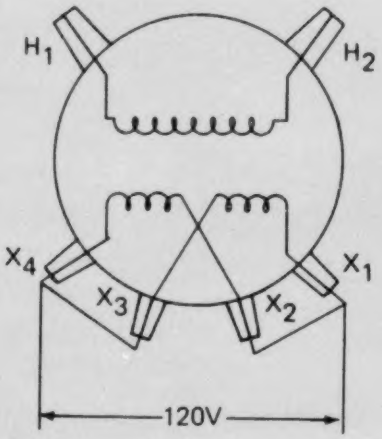
D. Place tap changers on same position on transformers to be banked or paralleled

E. Match the impedance on each of the transformers

INFORMATION SHEET

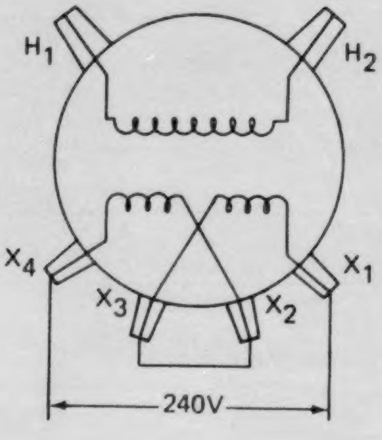
VIII. Secondary connections on four-bushing transformers

A. 120-volt secondary



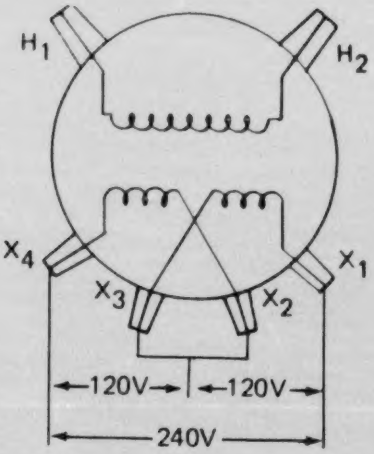
(NOTE: Transformers that are 167 KVA and larger may be equipped with four secondary bushings.)

B. 240-volt secondary



INFORMATION SHEET

C. 120/240-volt secondary



(NOTE: The secondary voltage rating may be 120/240, 240/480, or 277/480 on any of the transformers shown in A, B, and C.)

IX. Method of connecting wye and delta transformers to a primary line

A. 12470 Grd Y/7200 or 24940 Grd Y/14400 indicates reduced insulation on the neutral end of the primary winding--Connect primary side phase to ground

B. 2400, 12000, or 13800 indicates a winding for delta connection--Connect primary side phase to phase

X. Steps to find a faulted transformer in a bank

A. Observe high side fuses for blown fuse

B. Check secondary voltage phase to phase

C. Disconnect primary and secondary leads

D. Connect each transformer as a single unit and check secondary voltage

INFORMATION SHEET

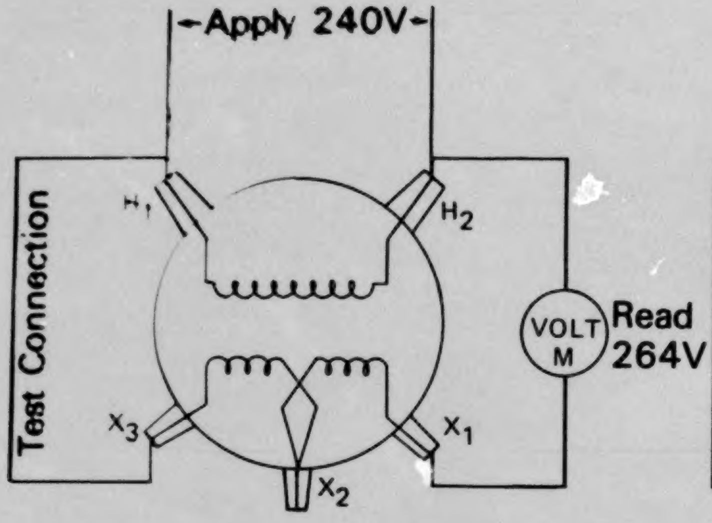
XI. Precautions to observe with transformer banks

A. Consider all primary and secondary parts energized unless primary and secondary of all transformers are disconnected

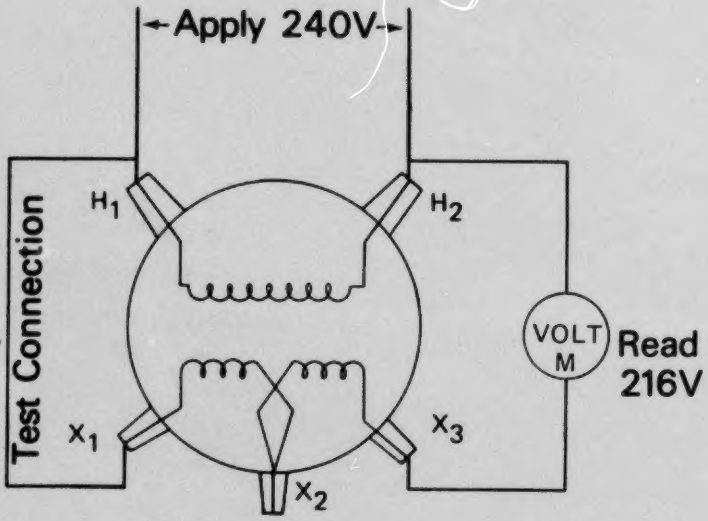
(NOTE: Backfeed from a consumer's generator or other power source could energize the transformer bank from the secondary side. The high side of the transformer would be energized at primary voltage.)

B. Open disconnect switches to remove secondary load before energizing transformer

Transformer Polarity



ADDITIVE POLARITY



SUBTRACTIVE POLARITY

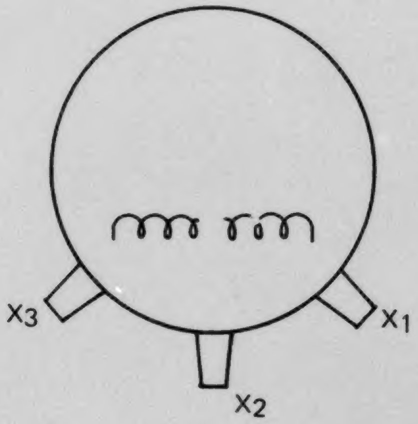
Transformers Of Different Polarity May Be Banked By Changing Either The Primary Or Secondary Leads On One Transformer.

TRANSFORMER CONNECTIONS AND BANKING
UNIT III

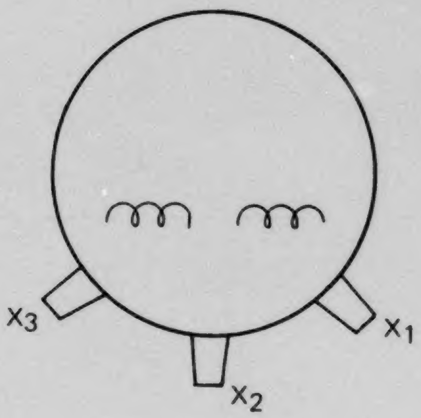
ASSIGNMENT SHEET #1--CONNECT TRANSFORMER SECONDARY COILS IN SERIES AND PARALLEL

Using the following diagrams, draw in the connections.

1. Series



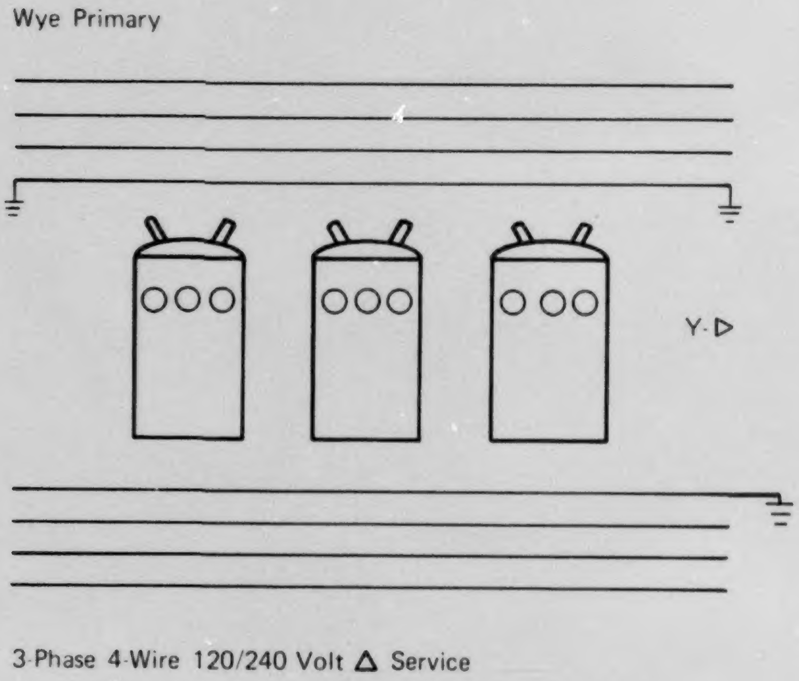
2. Parallel



TRANSFORMER CONNECTIONS AND BANKING
UNIT III

ASSIGNMENT SHEET #2--CONNECT A WYE-DELTA BANK FOR THREE-PHASE FOUR-WIRE 120/240-VOLT SERVICE

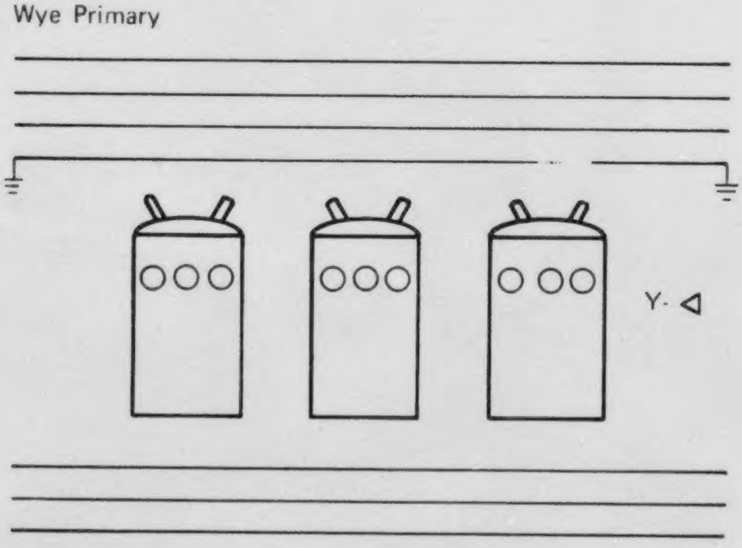
Using the following diagram, draw in the connections.



TRANSFORMER CONNECTIONS AND BANKING
UNIT III

ASSIGNMENT SHEET #3--CONNECT A WYE-DELTA BANK FOR THREE-PHASE THREE-WIRE 240-VOLT SERVICE

Using the following diagram, draw in the connections.

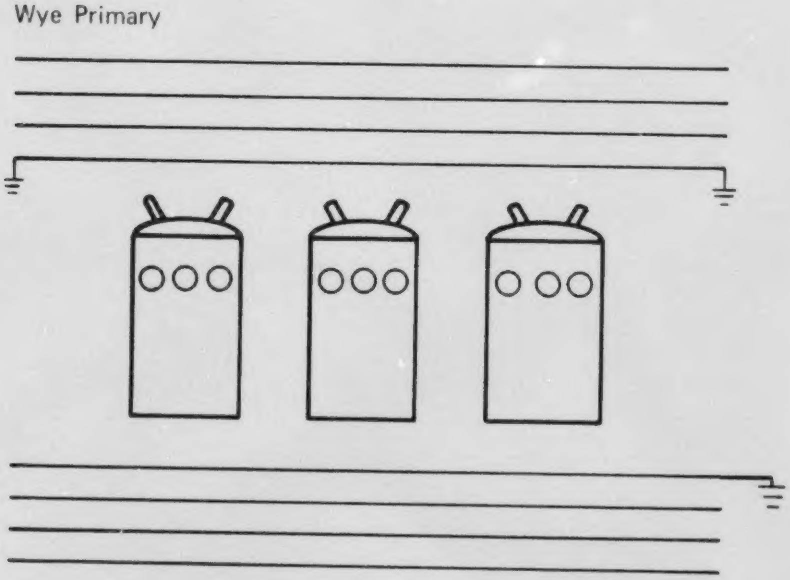


3-Phase 3-Wire 240 Volt △ Service

TRANSFORMER CONNECTIONS AND BANKING
UNIT III

ASSIGNMENT SHEET #4--CONNECT A WYE-WYE BANK FOR THREE-PHASE FOUR-WIRE 120/208-VOLT SERVICE

Using the following diagram, draw in the connections.

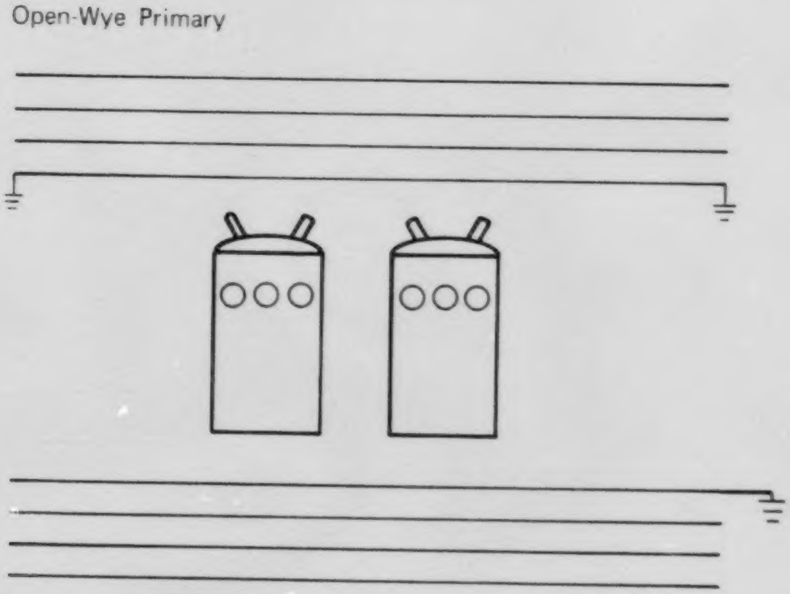


3-Phase 4-Wire 120/208 Volt Y Service

TRANSFORMER CONNECTIONS AND BANKING
UNIT III

ASSIGNMENT SHEET #5--CONNECT AN OPEN-WYE OPEN-DELTA BANK FOR THREE-PHASE FOUR-WIRE 120/240-VOLT SERVICE

Using the following diagram, draw in the connections.

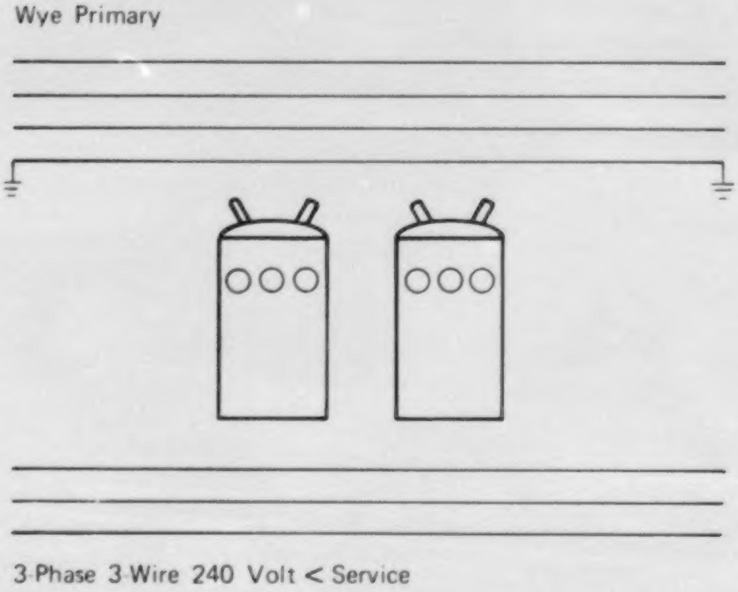


3-Phase 4-Wire 120/240 Volt △ Service

TRANSFORMER CONNECTIONS AND BANKING
UNIT III

ASSIGNMENT SHEET #6--CONNECT AN OPEN-WYE OPEN-DELTA BANK FOR THREE-PHASE THREE-WIRE 240-VOLT SERVICE

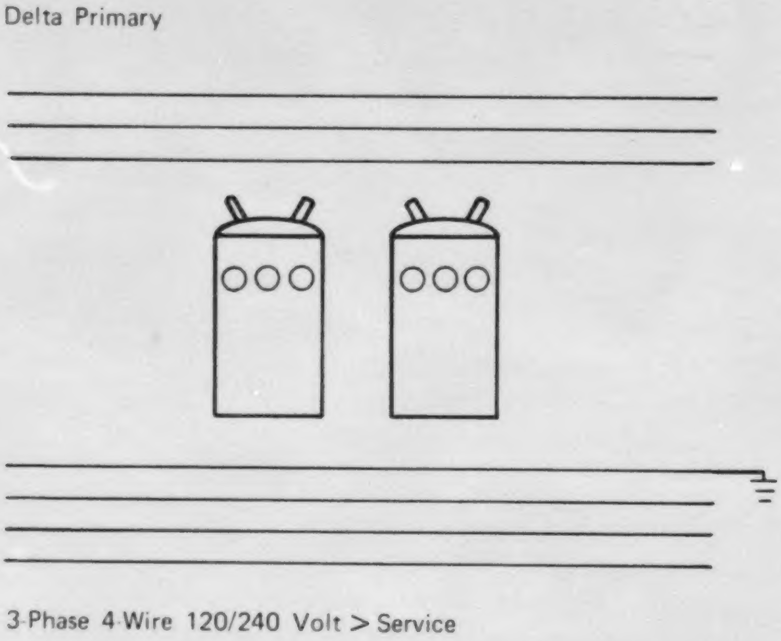
Using the following diagram, draw in the connections.



TRANSFORMER CONNECTIONS AND BANKING
UNIT III

ASSIGNMENT SHEET #7--CONNECT AN OPEN-DELTA OPEN-DELTA BANK FOR THREE-PHASE FOUR-WIRE 120/240-VOLT SERVICE

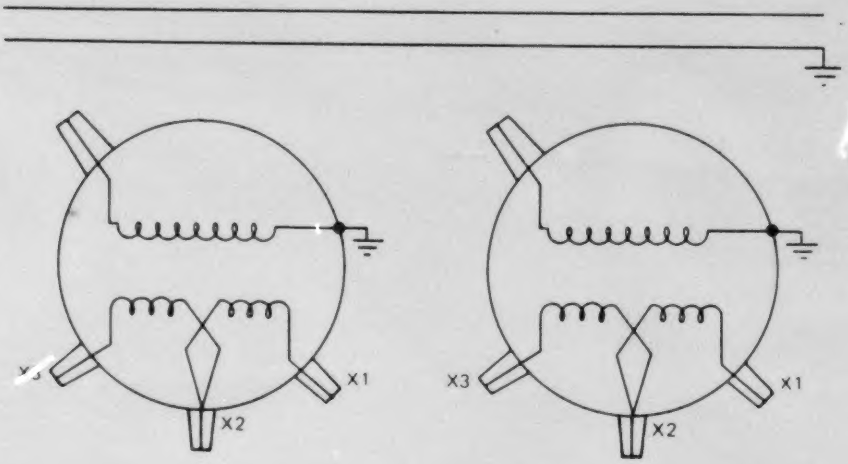
Using the following diagram, draw in the connections.



TRANSFORMER CONNECTIONS AND BANKING
UNIT III

ASSIGNMENT SHEET #8--CONNECT TWO SINGLE-BUSHING TRANSFORMERS IN PARALLEL

Using the following diagram, draw in the connections.

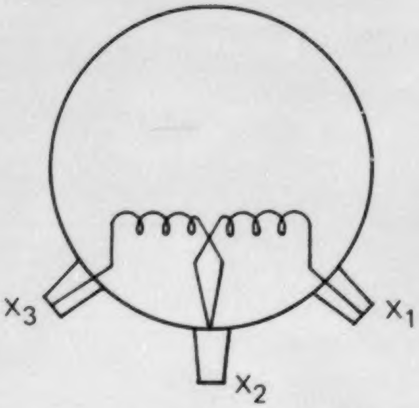


TRANSFORMER CONNECTIONS AND BANKING
UNIT III

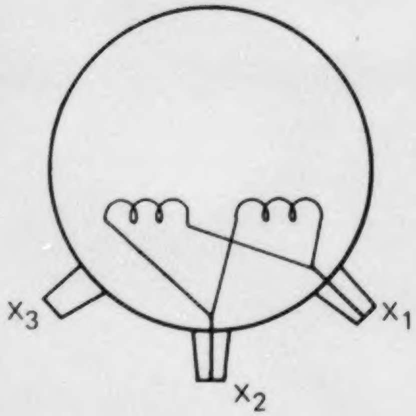
ANSWERS TO ASSIGNMENT SHEETS

Assignment Sheet #1

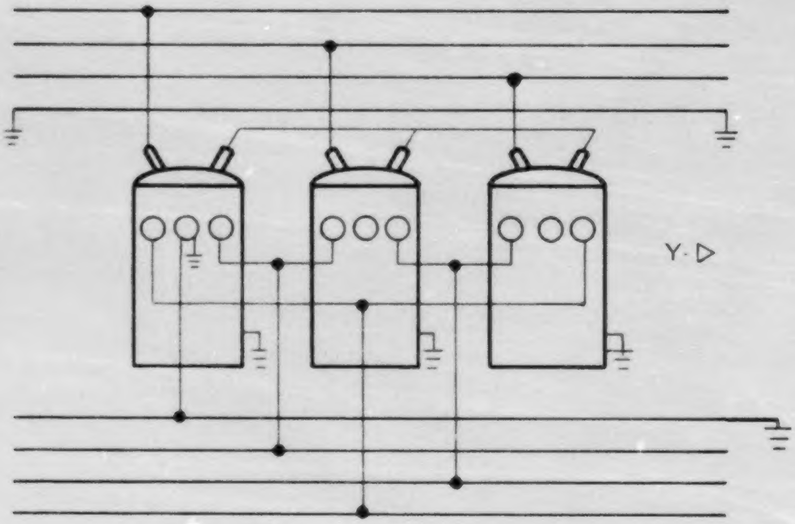
1. Series



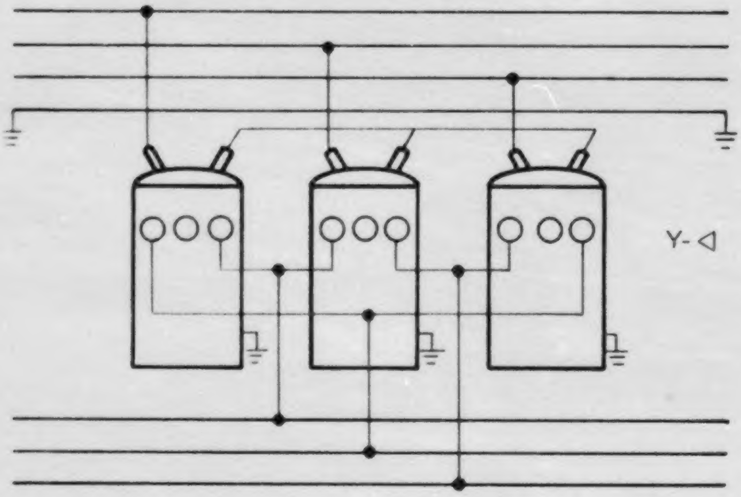
2. Parallel



Assignment Sheet #2



Assignment Sheet #3



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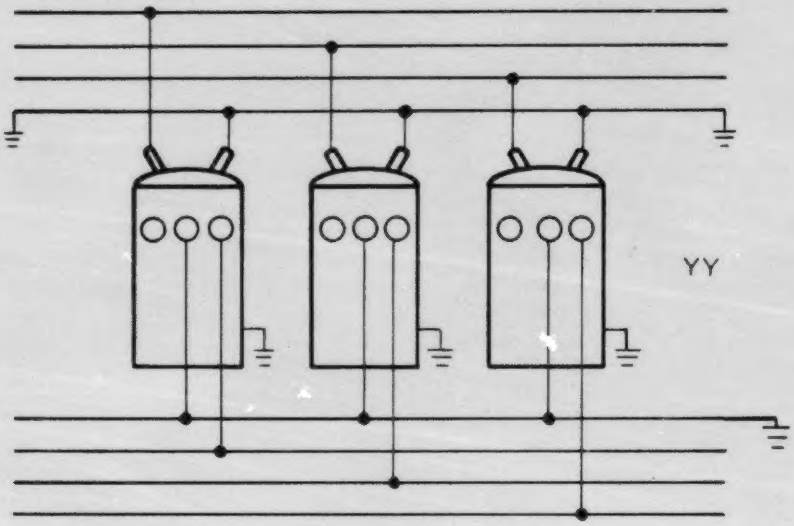

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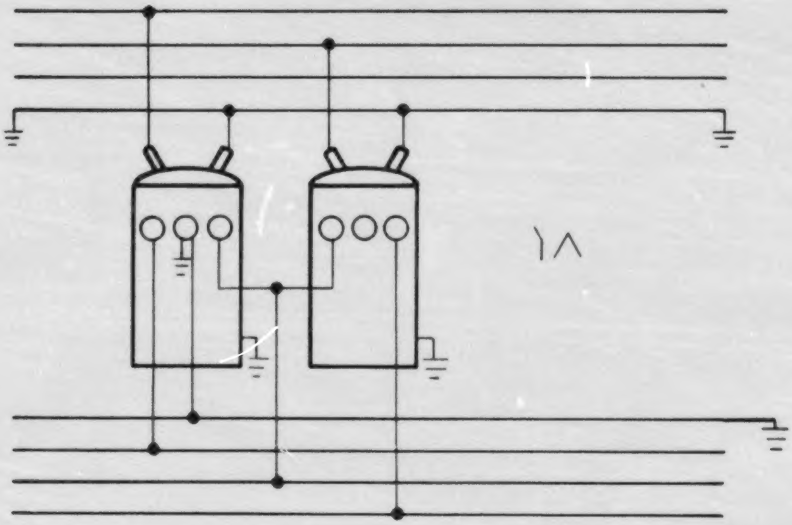
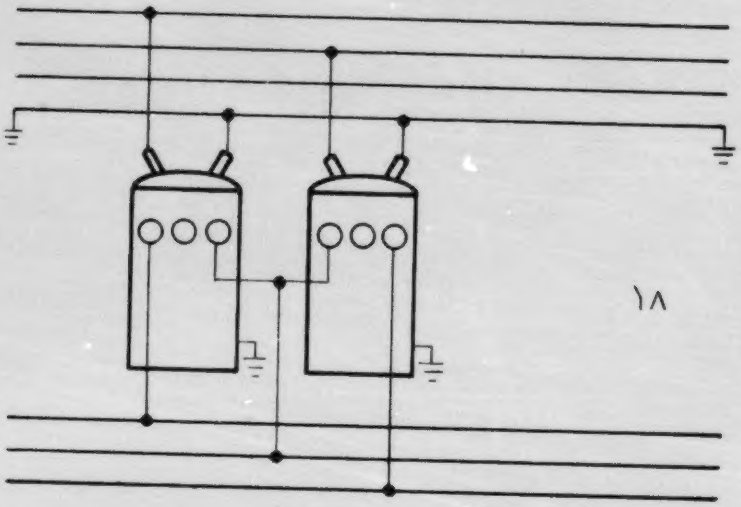
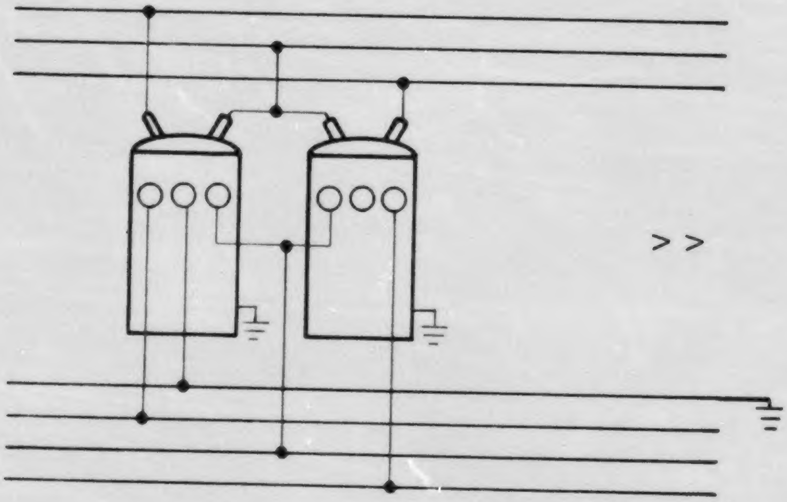


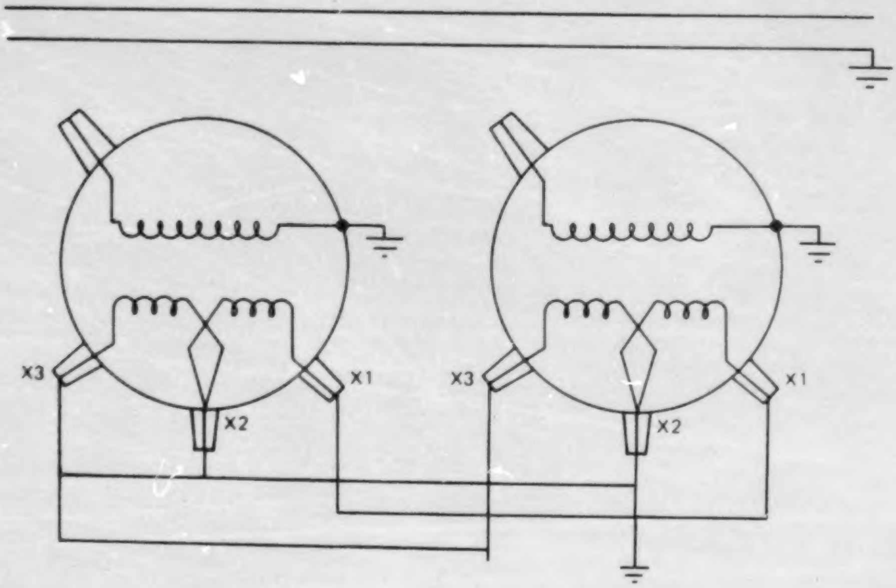
Assignment Sheet #6



Assignment Sheet #7



Assignment Sheet #8



TRANSFORMER CONNECTIONS AND BANKING
UNIT III

TEST

NAME ______________________ SCORE ______________________

1. Match the terms on the right to the correct definitions.

_____a. Designation of relative current flow and purely a function of how the leads are brought out of a transformer

_____b. Instantaneous voltages of the two transformer windings add to each other when connected in sequence

_____c. Instantaneous voltages of the two transformer windings subtract from each other when connected in sequence

_____d. Symbol (Δ) used to identify the diagrams that describe a system using three transformers whose secondary windings are connected in series

_____e. Symbol (Y) sometimes used to identify diagrams that describe a system using three transformers whose secondary windings are paralleled

_____f. Symbol (∧) used to identify a connection that uses two transformers for a three-phase service

_____g. Term used to identify the high voltage leg of a four-wire delta-connected secondary

_____h. Combined effect of resistance and inductive reactance

1. Additive polarity
2. Subtractive polarity
3. Polarity
4. Open delta
5. Wild leg
6. Star or wye
7. Impedance
8. Delta

2. Match the symbols on the right to the correct meanings.

_____a. Separates voltage rating of high side and low side windings

_____b. Separates tap voltage and voltage rating of one winding

_____c. Separates windings that may be connected in parallel or series

_____d. Indicates a winding suitable for phase-to-ground connection

_____e. Indicates high voltage connections

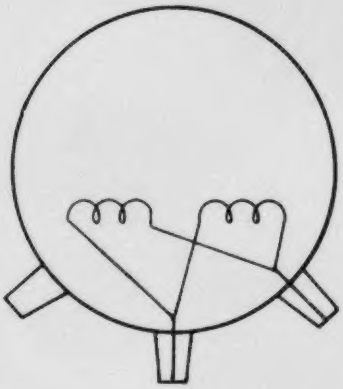
_____f. Indicates low voltage connections

_____g. Indicates the primary ground or common connection

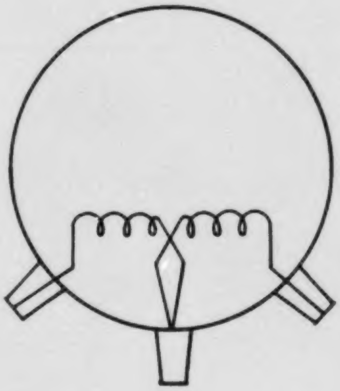
_____h. Indicates the secondary ground connection

1. H_o
2. Y
3. /
4. _____
5. X
6. X_o
7. X_1, X_2, X_3, and X_4
8. H_1, H_2, and H_3

3. Identify the following types of secondary coil connections for three-wire service.

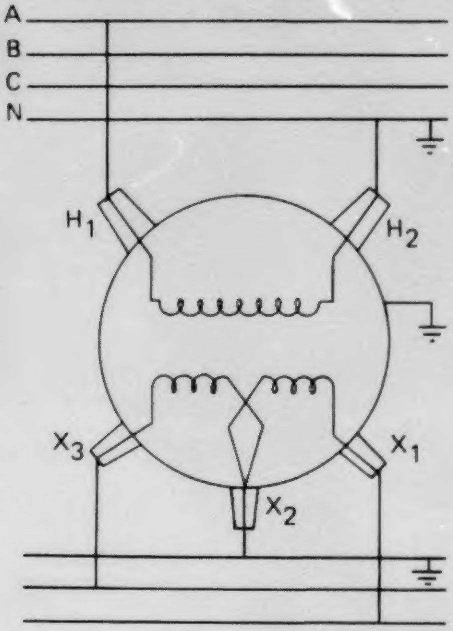


a. ______________________



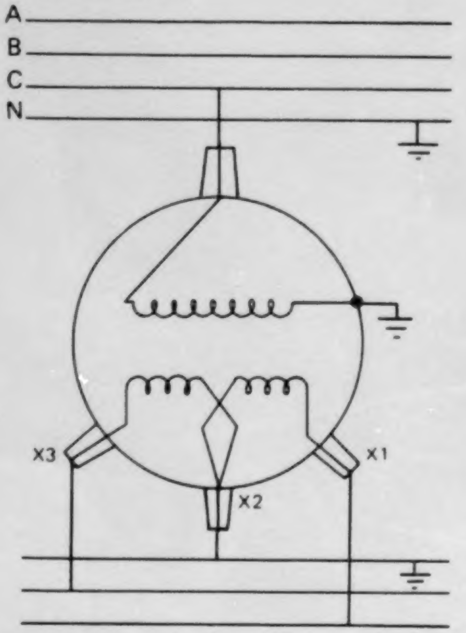
b. ______________________

4. Identify the following single transformer connections.



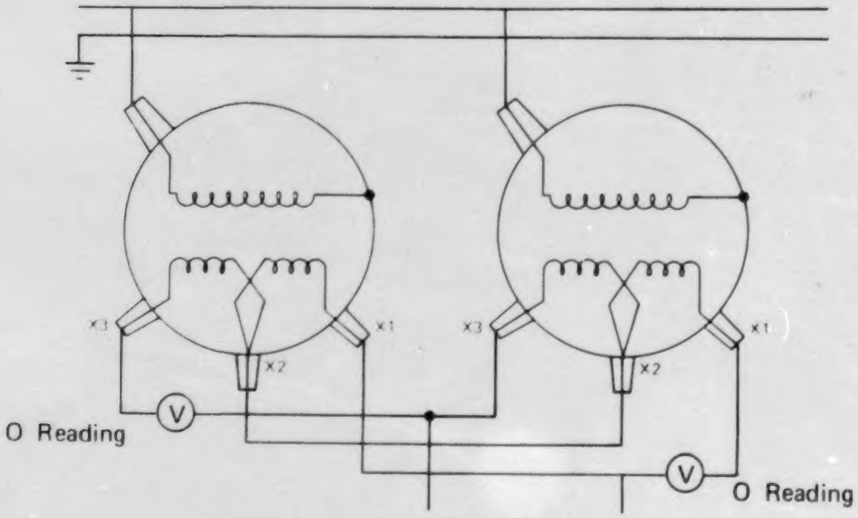
a. ____________________

____



b. ____________________

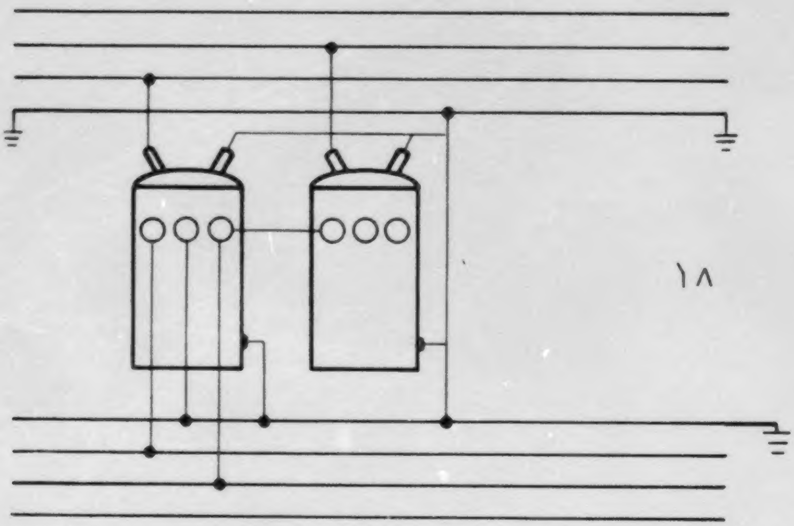
____



c. ____________________

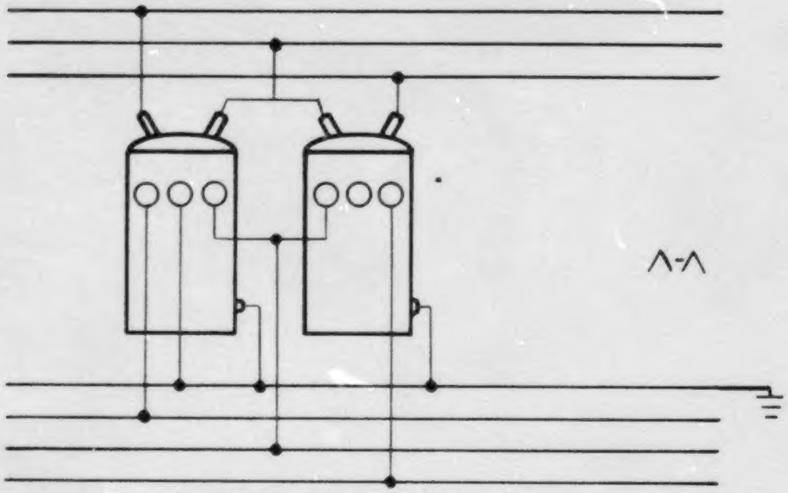
____

5. Identify the following two-transformer banks by stating the types of primary and secondary connections.



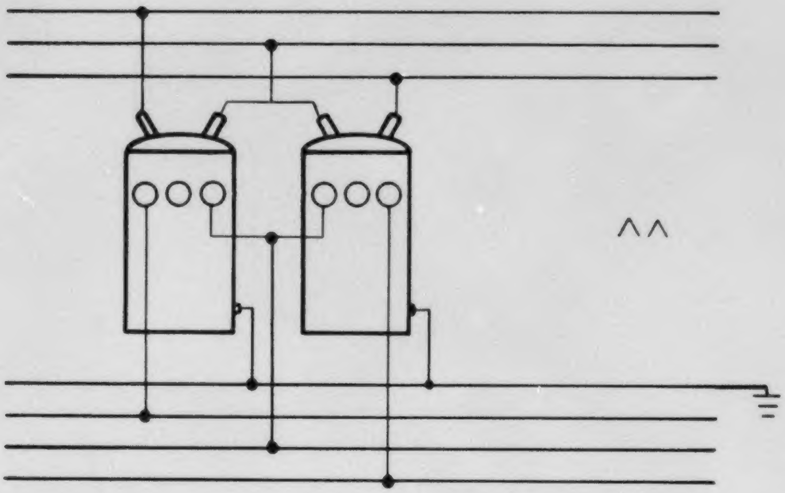
a. ______________________________ primary

b. ______________________________ secondary



c. ______________________________ primary

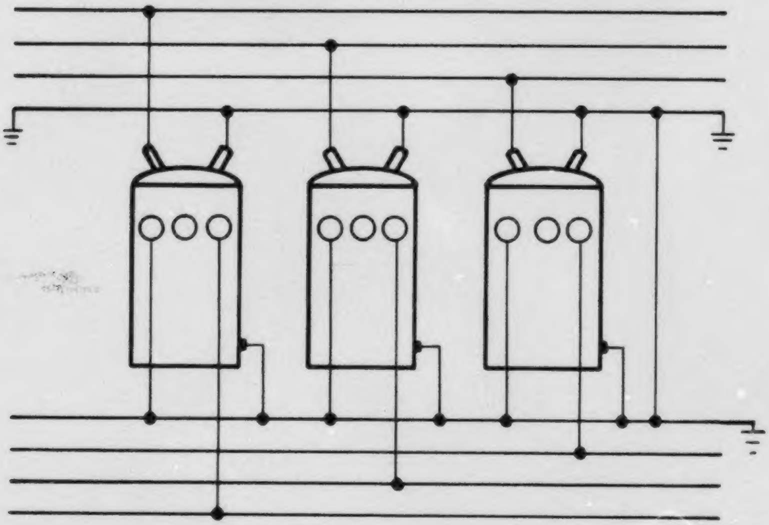
d. ______________________________ secondary



e. ______________________ primary

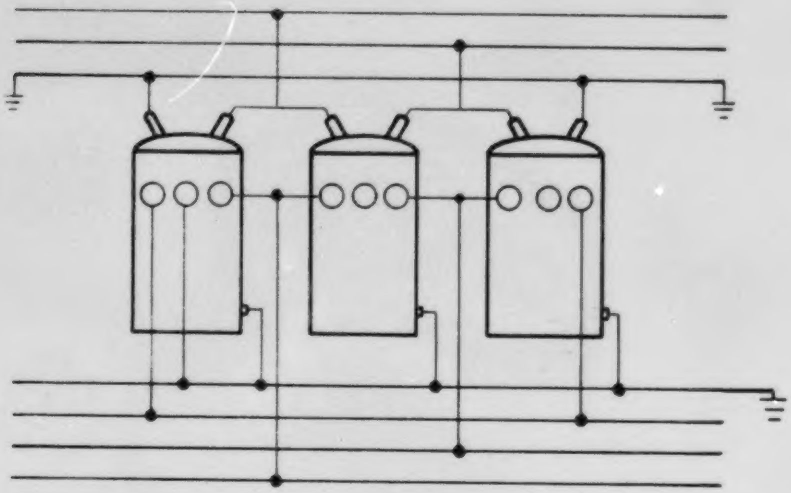
f. ______________________ secondary

6. Identify the following types of primary and secondary connections for three-transformer banks.



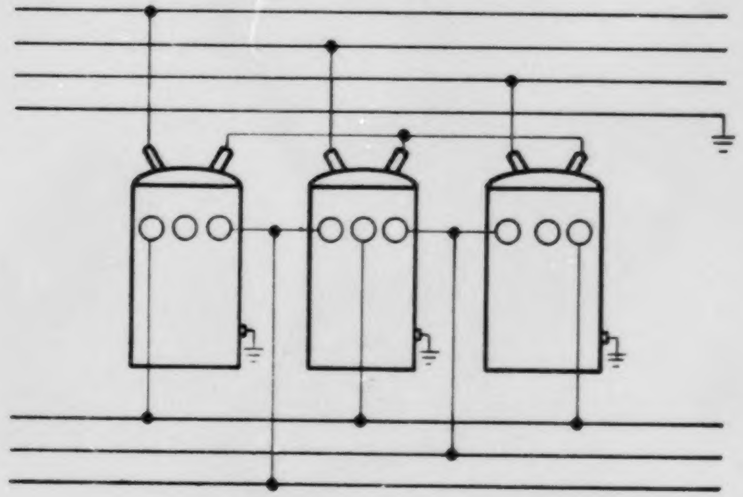
a. ______________________ primary

b. ______________________ secondary



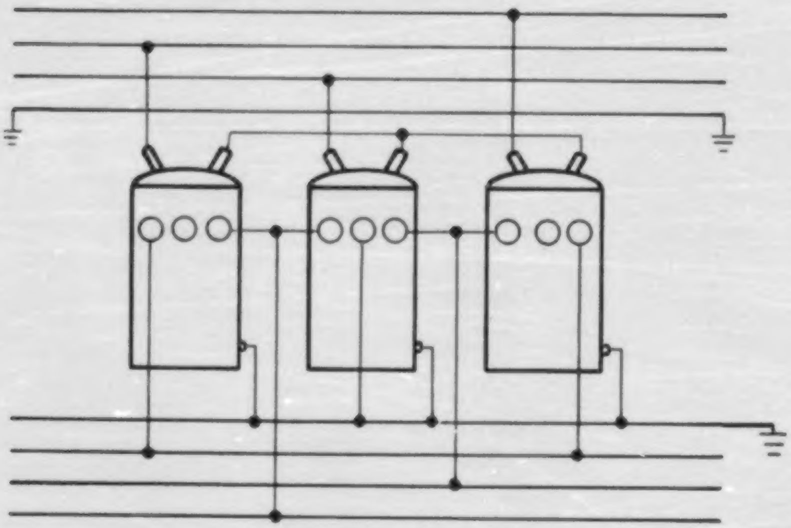
c. ____ primary

d. ____ secondary



e. ____ primary

f. ____ secondary



g. ________________________________ primary

h. ________________________________ secondary

7. List five precautions to observe when selecting transformers to be banked or paralleled.

a. ____

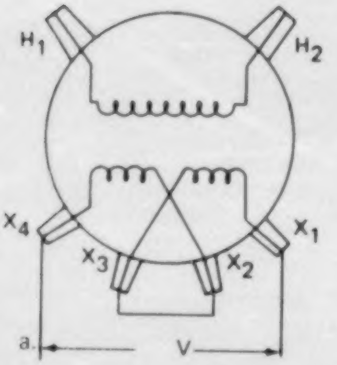
b. ____

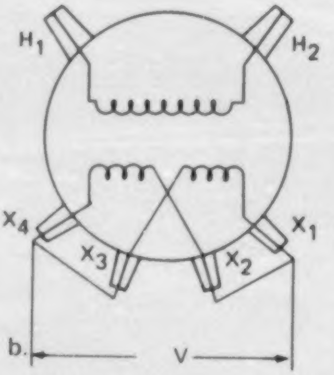
c. ____

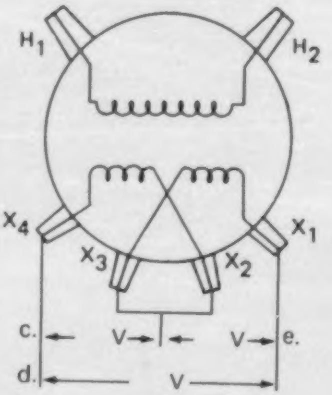
d. ____

e. ____

8. Identify the following four-bushing transformers by stating the voltage produced from each connection.







9. State the correct method of connecting the following voltage transformers to a primary line.

   a. 12470 Grd Y/7200 -- ______________________________

   b. 13,800 -- ______________________________

10. Arrange in order the following steps to find a faulted transformer in a bank.

    ______a. Disconnect primary and secondary leads

    ______b. Connect each transformer as a single unit and check secondary voltage

    ______c. Observe high side fuses for blown fuse

    ______d. Check secondary voltage phase to phase

11. State two precautions to observe with transformer banks.

    a. ______________________________

    ____

    ____

    b. ______________________________

    ____

    ____

12. Connect transformer secondary coils in series and parallel.

13. Connect a wye-delta bank for three-phase four-wire 120/240-volt service.

14. Connect a wye-delta bank for three-phase three-wire 240-volt service.

15. Connect a wye-wye bank for three-phase four-wire 120/208-volt service.

16. Connect an open-wye open delta bank three-phase four-wire 120/240-volt service.

17. Connect an open-wye open-delta bank for three-phase three-wire 240-volt service.

18. Connect an open-delta open-delta bank for three-phase four-wire 120/240-volt service.

19. Connect two single-bushing transformers in parallel.

    (NOTE: If activities 12-19 have not been accomplished prior to the test, ask the instructor when they should be completed.)

TRANSFORMER CONNECTIONS AND BANKING
UNIT III

ANSWERS TO TEST

1. Match the terms on the right to the correct definitions.

__3__ a. Designation of relative current flow and purely a function of how the leads are brought out of a transformer

__1__ b. Instantaneous voltages of the two transformer windings add to each other when connected in sequence

__2__ c. Instantaneous voltages of the two transformer windings subtract from each other when connected in sequence

__8__ d. Symbol (Δ) used to identify the diagrams that describe a system using three transformers whose secondary windings are connected in series

__6__ e. Symbol (Y) sometimes used to identify diagrams that describe a system using three transformers whose secondary windings are paralleled

__4__ f. Symbol (Λ) used to identify a connection that uses two transformers for a three-phase service

__5__ g. Term used to identify the high voltage leg of a four-wire delta-connected secondary

__7__ h. Combined effect of resistance and inductive reactance

1. Additive polarity
2. Subtractive polarity
3. Polarity
4. Open delta
5. Wild leg
6. Star or wye
7. Impedance
8. Delta

2. Match the symbols on the right to the correct meanings.

4 a. Separates voltage rating of high side and low side windings

3 b. Separates tap voltage and voltage rating of one winding

5 c. Separates windings that may be connected in parallel or series

2 d. Indicates a winding suitable for phase-to-ground connection

8 e. Indicates high voltage connections

7 f. Indicates low voltage connections

1 g. Indicates the primary ground or common connection

6 h. Indicates the secondary ground connection

1. H_o
2. Y
3. /
4. ______
5. X
6. X_o
7. X_1, X_2, X_3, and X_4
8. H_1, H_2, and H_3

3. Identify the following single transformer connections.

   a. Parallel connected

   b. Series connected

4. Identify the following single transformer connections for three-wire service.

   a. Two bushing primary connection

   b. Single-bushing primary connection

   c. Two single-bushing transformers paralleled

5. Identify the following two-transformer banks by stating the types of primary and secondary connections.

   a. Open wye primary

   b. Open delta secondary

   c. Open delta primary

   d. Open delta secondary

   e. Open delta primary

   f. Open delta secondary

6. Identify the following types of primary and secondary connections for three-transformer banks.

   a. Wye primary

   b. Wye secondary

   c. Delta primary

   d. Delta secondary

   e. Wye primary

   f. Delta secondary

   g. Wye primary

   h. Delta secondary

7. List five precautions to observe when selecting transformers to be banked or paralleled.

   a. Check the polarity marked on nameplate

   b. Check the primary voltage rating

   c. Check secondary voltage rating

   d. Place tap changers on same position on transformers to be banked or paralleled

   e. Match the impedance on each of the transformers

8. Identify the following four bushing transformers by stating the voltage produced from each connection.

   a. 240

   b. 120

   c. 120

   d. 240

   e. 120

9. State the correct method of connecting the following voltage transformers to a primary line.

   a. 12470 Grd Y/7200--Connect phase to ground

   b. 13,800--Connect phase to phase

10. Arrange in order the following steps to find a faulted transformer in a bank.

    __3__ a. Disconnect primary and secondary leads

    __4__ b. Connect each transformer as a single unit and check secondary voltage

    __1__ c. Observe high side fuses for blown fuse

    __2__ d. Check secondary voltage phase to phase

11. State two precautions to observe with transformer banks.

    a. Consider all primary and secondary parts energized unless primary and secondary of all transformers are disconnected

    b. Open disconnect switches to remove secondary load before energizing transformer

12. Connect transformer secondary coils in series and parallel.

13. Connect a wye-delta bank for three-phase four-wire 120/240-volt service.

14. Connect a wye-delta bank for three-phase three-wire 240-volt service.

15. Connect a wye-wye bank for three-phase four-wire 120/208-volt service.

16. Connect an open-wye open-delta bank for three-phase four-wire 120/240-volt service.

17. Connect an open-wye open-delta bank for three-phase three-wire 240-volt service.

18. Connect an open-delta open-delta bank for three-phase four-wire 120/240-volt service.

19. Connect two single-bushing transformers in parallel.

(NOTE: Activities 12-19 will be evaluated to the satisfaction of the instructor.)

PHASING
UNIT IV

UNIT OBJECTIVE

After completion of this unit, the student should be able to state methods of determining phase rotation and state the procedure for changing direction of rotation of a three-phase motor. The student should be able to label distribution phases. This knowledge will be evidenced by scoring 85 percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms commonly associated with phasing to the correct definitions.
2. List elements of phasing.
3. State methods of determining phase rotation.
4. State the correct procedure for changing the direction of rotation of a three-phase motor.
5. Arrange in order the steps to follow when phasing circuits with a phasing meter.
6. Arrange in order the steps to follow to identify distribution phases.
7. Label substation distribution phases.

PHASING
UNIT IV

SUGGESTED ACTIVITIES

I. Suggested activities for instructor:

   A. Provide student with objective sheet.

   B. Provide student with information and assignment sheets.

   C. Make transparencies.

   D. Discuss unit and specific objectives.

   E. Discuss information and assignment sheets.

   F. Give test.

II. Unit references:

   A. Rural Electrification Administration. *Standard for Preparation of Circuit Diagrams for Electrical Distribution Systems.* REA Bulletin 60-1. Washington, D.C.: U.S. Department of Agriculture, 1955.

   B. Marcus, Abraham, and Marcus, William. *Basic Electricity.* 4th ed. Englewood Cliffs, New Jersey: Prentice-Hall Inc., 1974.

PHASING
UNIT IV

INFORMATION SHEET

I. Terms and definitions

   A. Phase sequence--Order in which the voltages of a three-phase circuit appear

   B. Phasing map--Map which identifies each phase leaving a substation

   C. Phase identification--Identifying a phase by color or number from a phasing map or at a substation

   D. Circuit phasing--Determining potential difference between circuits of different sources to parallel the circuits

   E. Phase balance--Distribution of single-phase loads as evenly as possible on a three-phase circuit

   F. Phase rotation--Similar to phase sequence in a three-phase circuit

   G. Phase difference--Time in electrical degrees by which one wave leads or lags another (Transparency 1)

   H. Phase angle--Relationship of current leaving the secondary of a transformer to the current entering the primary

II. Elements of phasing

   A. Identification of distribution phases

   B. Phasing of distribution circuits

   C. Determining phase sequence

III. Methods of determining rotation

   A. Connect a phase sequence indicator to a three-phase circuit (Transparency 2)

   B. Check the direction of rotation of a three-phase motor

   (NOTE: If work is to be done on a three-phase circuit, the phase sequence or motor rotation should be checked first so that the sequence will remain the same when the work is completed.)

IV. Procedure for changing direction of rotation of a three-phase motor--Interchange any two phases either on the primary or secondary side of the transformer bank

INFORMATION SHEET

V. Steps to follow when phasing circuits with a phasing meter (Transparency 3)

A. Connect phasing meter to two phases of different sources

B. Move one lead of phasing meter from phase to phase on the same source until there is a zero reading on the meter

C. Mark the zero reading phases

Examples: X and X1, Y and Y1, Z and Z1

D. Connect meter to another two phases of different sources

E. Continue check until there is a zero reading between all sets of phases

(NOTE: A low reading may be indicated if there is a slight difference in potential in two phases that are in sequence. If two phases check out with a zero or low reading and the other four do not, the phase sequence is different at the two sources.)

VI. Steps to identify distribution phases

A. Select the circuit which runs north or close to north from a substation

B. Face the direction of the load

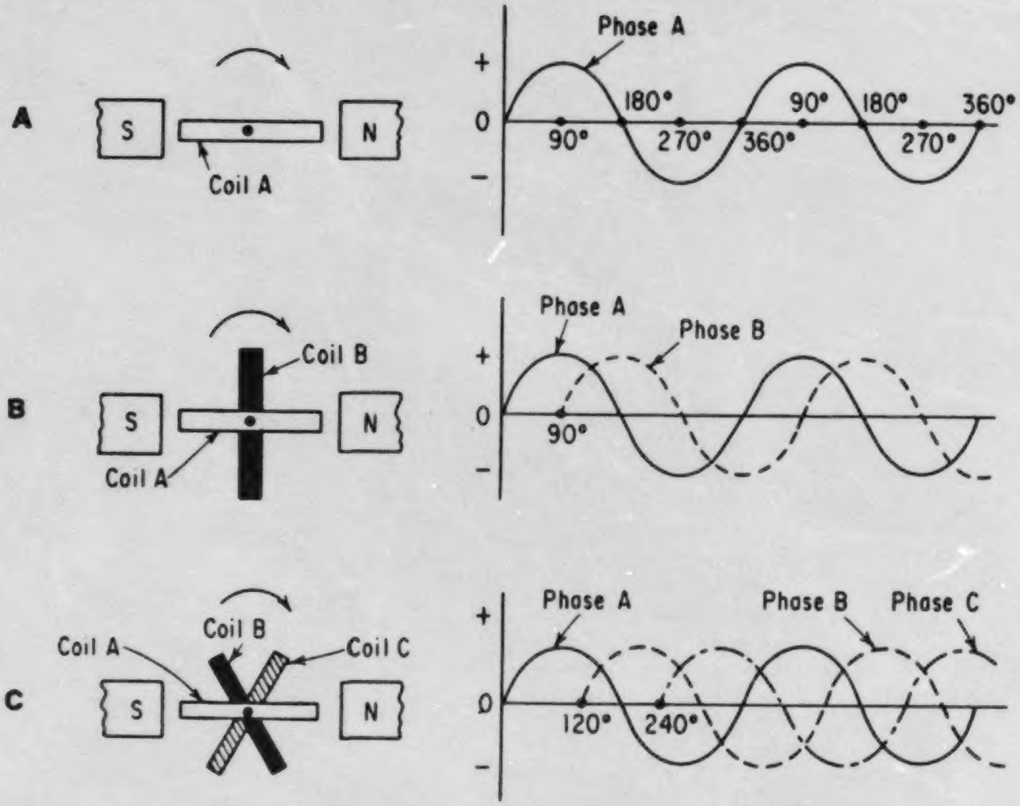
C. Identify the phases as A, B, and C from left to right

D. Identify the circuit to the right or clockwise direction from the circuit running north as 2A, 2B, and 2C from left to right

E. Identify all circuits in a clockwise direction in sequence with the next circuit to the right as 3A, 3B, and 3C

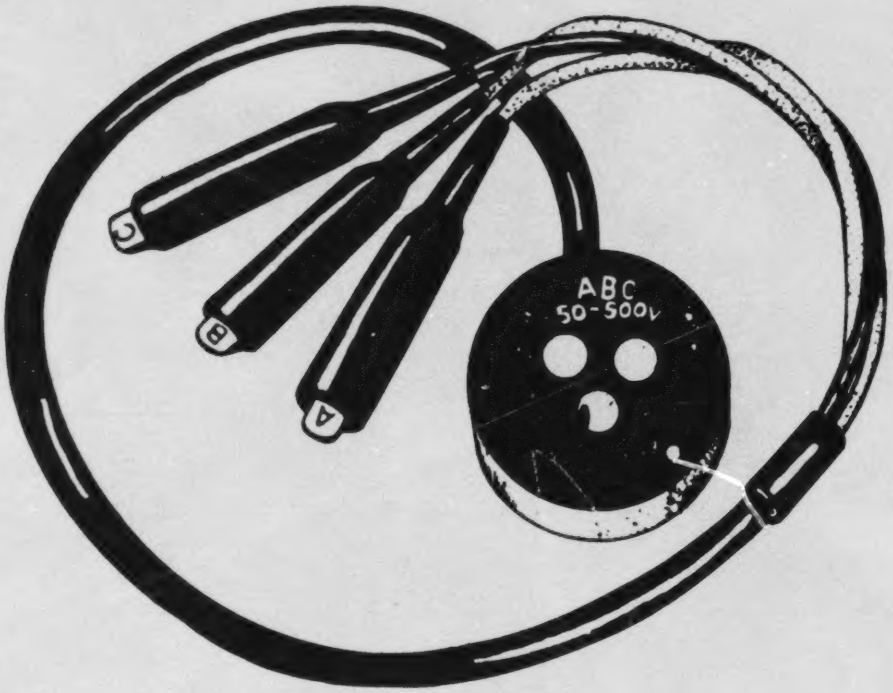
(NOTE: The phase designation should remain on each phase to the end of the line with all line extensions or taps designated the same as the phase to which the tap is connected.)

Phase Difference In Electrical Degrees



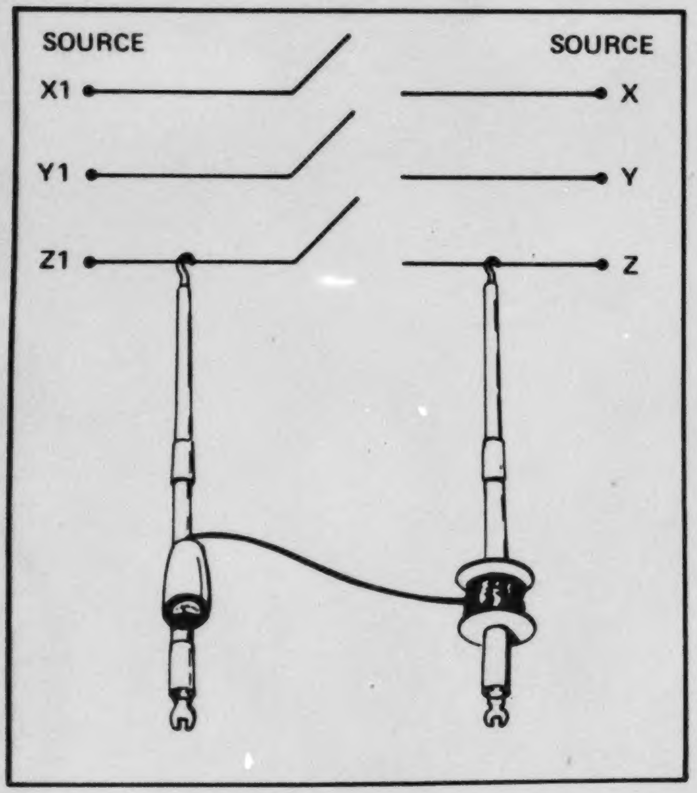
A. Single-phase B. Two-phase Generator C. Three-phase Generator

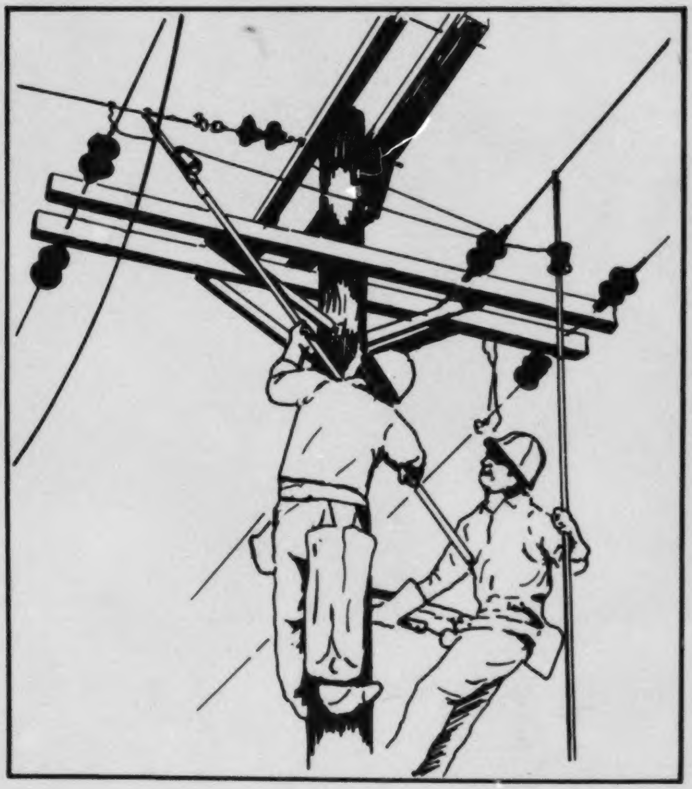
Phase Sequence Indicator



Leads are color-coded red, white, and blue. A small 3-phase motor in the indicator rotates according to the phase sequence

Phasing Circuits To Be Paralleled

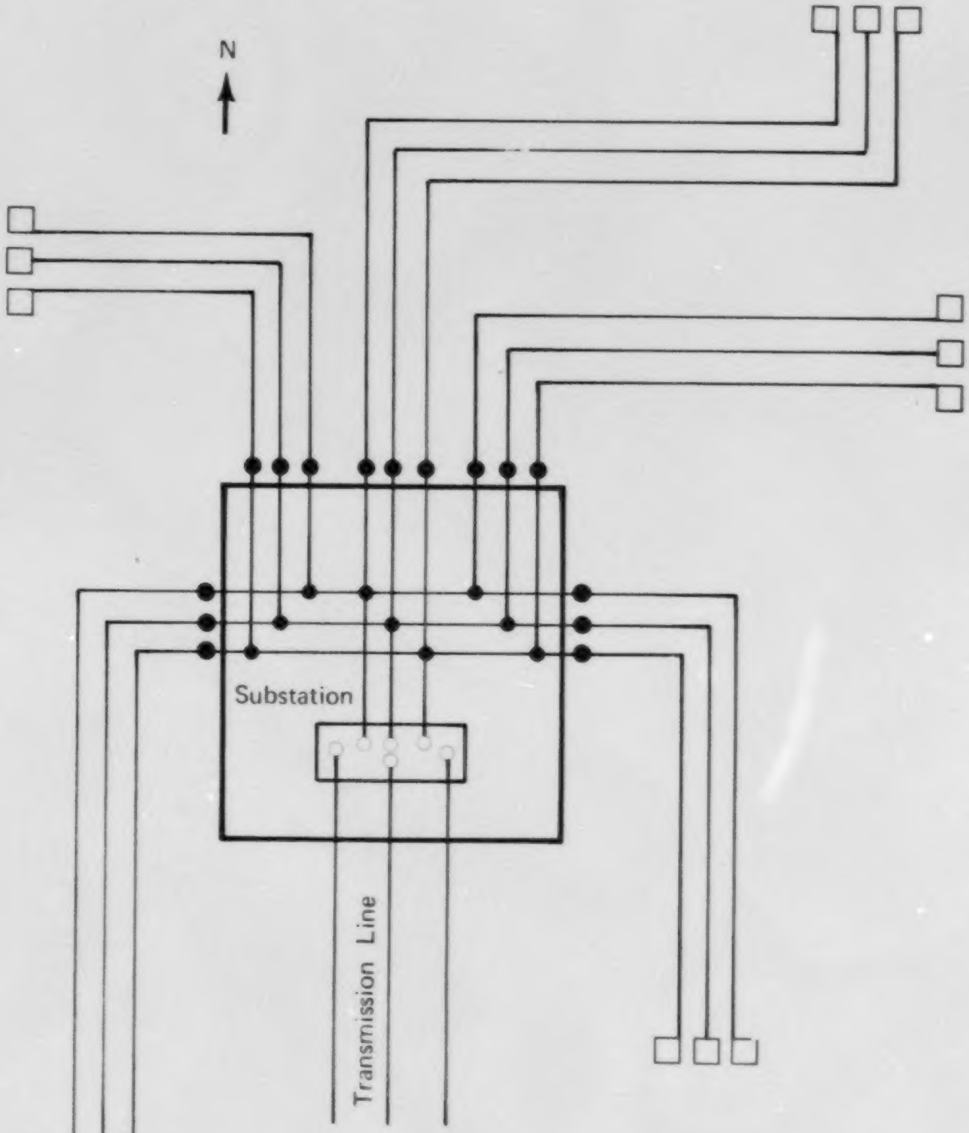




PHASING
UNIT IV

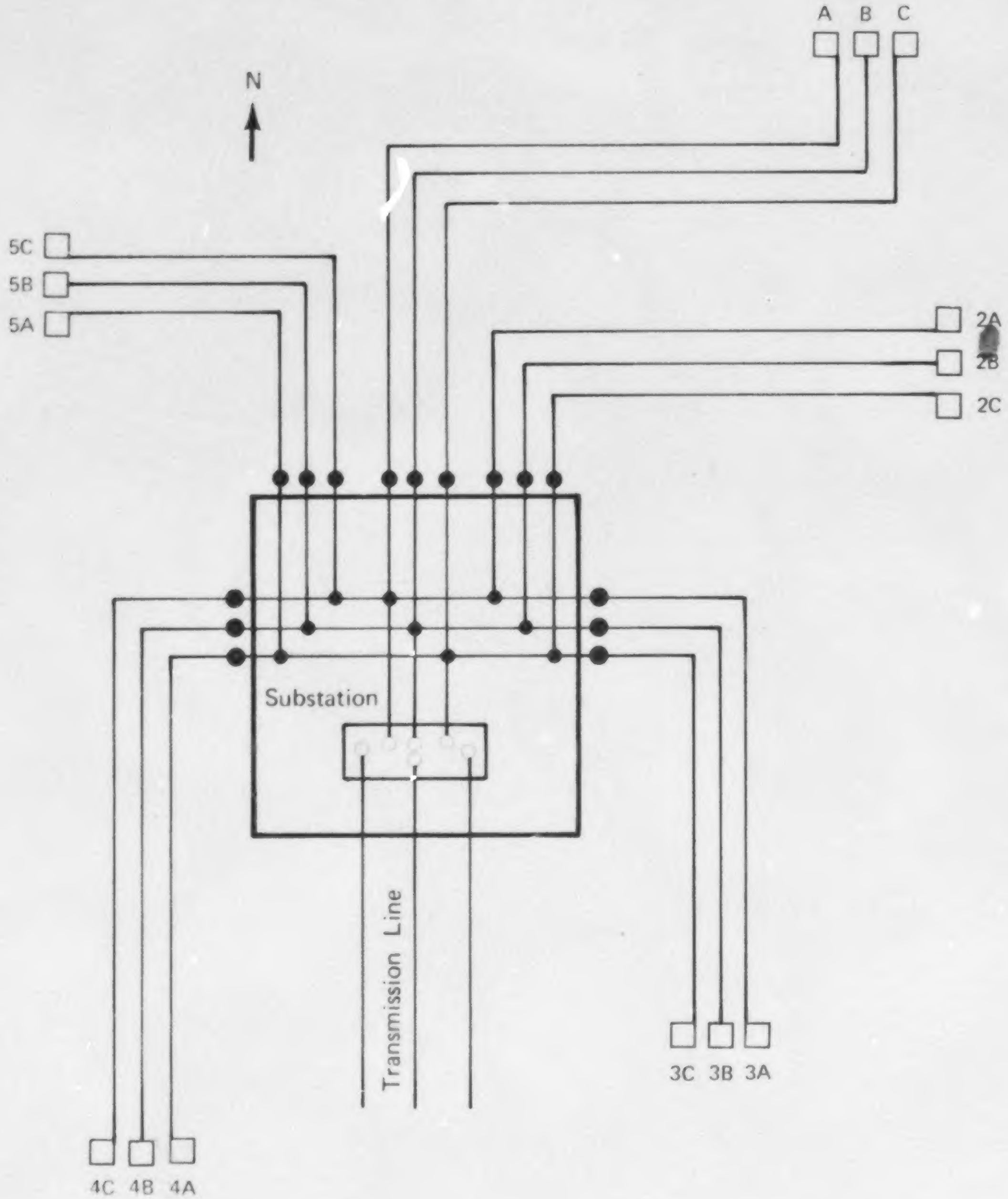
ASSIGNMENT SHEET #1--LABEL SUBSTATION DISTRIBUTION PHASES

Label each phase, starting with the circuit which goes to the north.



PHASING
UNIT IV

ANSWERS TO ASSIGNMENT SHEET #1



PLT - 157-E

PHASING
UNIT IV

TEST

NAME ______________________ SCORE ______________

1. Match the terms on the right to the correct definitions.

_____a. Order in which the voltages of a three-phase circuit appear

_____b. Map which identifies each phase leaving a substation

_____c. Identifying a phase by color or number from a phasing map or at a substation

_____d. Determining potential difference between circuits of different sources to parallel the circuits

_____e. Distribution of single-phase loads as evenly as possible on a three-phase circuit

_____f. Similar to phase sequence in a three-phase circuit

_____g. Time in electrical degrees by which one wave leads or lags another

_____h. Relationship of current leaving the secondary of a transformer to the current entering the primary

1. Phase balance
2. Phase sequence
3. Circuit phasing
4. Phase rotation
5. Phase identification
6. Phasing map
7. Phase angle
8. Phase difference

2. List three elements of phasing.

a. ______________________________

b. ______________________________

c. ______________________________

3. State two methods of determining rotation.

a. ______________________________

____

b. ______________ ______________

____

4. State the correct procedure for changing the direction of rotation of a three-phase motor.

____

____

____

5. Arrange in the correct order the steps to follow when phasing circuits with a phasing meter.

______a. Mark the zero reading phases

______b. Move one lead of phasing meter from phase to phase on the same source until there is a zero reading on the meter

______c. Connect phasing meter to two phases of different sources

______d. Continue check until there is a zero reading between all sets of phases

______e. Connect meter to another two phases of different sources

6. Arrange in the correct order the steps to follow to identify distribution phases.

______a. Identify the phases as A, B, and C from left to right

______b. Identify all circuits in a clockwise direction in sequence with the next circuit to the right as 3A, 3B, and 3C

______c. Face the direction of the load

______d. Select the circuit which runs north or close to north from a substation

______e. Identify the circuit to the right or clockwise direction from the circuit running north as 2A, 2B, and 2C from left to right

7. Label substation distribution phases.

(NOTE: If this activity has not been accomplished prior to the test, ask the instructor when it should be completed.)

PHASING
UNIT IV

ANSWERS TO TEST

1. Match the terms on the right to the correct definitions.

__2__ a. Order in which the voltages of a three-phase circuit appear

__6__ b. Map which identifies each phase leaving a substation

__5__ c. Identifying a phase by color or number from a phasing map or at a substation

__3__ d. Determining potential difference between circuits of different sources to parallel the circuits

__1__ e. Distribution of single-phase loads as evenly as possible on a three-phase circuit

__4__ f. Similar to phase sequence in a three-phase circuit

__8__ g. Time in electrical degrees by which one wave leads or lags another

__7__ h. Relationship of current leaving the secondary of a transformer to the current entering the primary

1. Phase balance
2. Phase sequence
3. Circuit phasing
4. Phase rotation
5. Phase identification
6. Phasing map
7. Phase angle
8. Phase difference

2. List three elements of phasing.

   a. Identification of distribution phases

   b. Phasing of distribution circuits

   c. Determining phase sequence

3. State two methods of determining rotation.

   a. Connect a phase sequence indicator to a three-phase circuit

   b. Check the direction of rotation of a three-phase motor

4. State the procedure for changing the direction of rotation of a three-phase motor.

   Interchange any two phases either on the primary or secondary side of the transformer bank

5. Arrange in the correct order the steps to follow when phasing circuits with a phasing meter.

   3 a. Mark the zero reading phases

   2 b. Move one lead of phasing meter from phase to phase on the same source until there is a zero reading on the meter

   1 c. Connect phasing meter to two phases of different sources

   5 d. Continue check until there is a zero reading between all sets of phases

   4 e. Connect meter to another two phases of different sources

6. Arrange in the correct order the steps to follow to identify distribution phases.

   3 a. Identify the phases as A, B, and C from left to right

   5 b. Identify all circuits in a clockwise direction in sequence with the next circuit to the right as 3A, 3B, and 3C

   2 c. Face the direction of the load

   1 d. Select the circuit which runs north or close to north from a substation

   4 e. Identify the circuit to the right or clockwise direction from the circuit running north as 2A, 2B, and 2C from left to right

7. Label substation distribution phases.

   (NOTE: This activity will be evaluated to the satisfaction of the instructor.)

LINE PATROL
UNIT I

UNIT OBJECTIVE

After completion of this unit, the student should be able to list specific conditions that should be observed during patrol and complete a line inspection form. This knowledge will be evidenced by scoring 85 percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. List types of line patrol.
2. Match types of line patrol to the specific purpose.
3. Select from a list items to observe when patrolling line.
4. Match items to the specific conditions to observe when patrolling a line.
5. List methods of line patrol.
6. Select from a list requirements of a line patroller.
7. List items to observe with line equipment.
8. Complete a line inspection form.

LINE PATROL
UNIT I

SUGGESTED ACTIVITIES

I. Suggested activities for instructor:

  A. Provide student with objective sheet.

  B. Provide student with information and assignment sheets.

  C. Discuss unit and specific objectives.

  D. Discuss information and assignment sheets.

  E. Take student to field to inspect line.

  F. Give test.

II. Unit reference--Kurtz, Edwin B., and Shoemaker, Thomas M. *The Lineman's and Cableman's Handbook*. 5th ed. New York: McGraw-Hill Book Co., 1976.

LINE PATROL
UNIT I

INFORMATION SHEET

I. Types of line patrol

   A. Regular

   B. Emergency

   C. Specific

   D. Follow-up

II. Purposes of line patrol

   A. Regular patrol--Examine and report the condition of each pole, insulator, and conductor and all right-of-ways

   B. Emergency patrol--Locate a fault or problem without delay to restore service or to prevent an outage

   C. Special patrol--Compile detailed information on an existing line for a line change such as a line move, a rebuild, or reconductoring

   D. Follow-up patrol--Determine the cause of a problem such as blinking lights or breaker operations

III. Items to observe when patrolling line

   A. Insulators

   B. Poles

   C. Washes near poles

   D. Woodpecker holes

   E. Foreign objects on poles

   F. Crossarms

   G. Ground wires

   H. Guys

   I. Hardware

   J. Tie wires

   K. Conductors

   L. Sag

INFORMATION SHEET

- M. Clearances
- N. Jumpers
- O. Trees
- P. Construction near line
- Q. Kites or kite string
- R. Line equipment
- S. Crossings
- T. Radio interference

IV. Specific conditions to observe when patrolling line

- A. Insulators--Cracks, chips, or blackening
- B. Poles--Leaning, washed out, or graded out
- C. Guys--Broken anchor rod or stretched conductor
- D. Ground wires--Loose connector at neutral or staples not driven into pole
- E. Conductors--Burned spots; broken or frayed strands
- F. Hardware--Loose nuts, washers, or connectors
- G. Trees--Near enough to blow into conductor or break off and fall onto conductor

  (NOTE: Burned spots in trees indicate that the trees have been touching or blowing into an energized conductor.)
- H. Crossarms--Cracks, splits or loose hardware
- I. Jumpers--Slack enough to blow into pole or equipment
- J. Sag--Insufficient separation of conductors
- K. Crossings--Insufficient clearance over road or from other utilities

V. Methods of line patrol

- A. Foot
- B. Vehicle
- C. Aircraft

INFORMATION SHEET

VI. Requirements of a line patroller

   A. Observe all parts of line being patrolled

   B. Distinguish between hazardous and nonhazardous conditions

   C. Make a written report of the line conditions observed

   D. Make a list of materials and equipment needed to make repairs

   E. Follow up on reported conditions to see that repairs are made

   (NOTE: A line inspection will be required in addition to patrols in order to make a complete inspection of pole conditions and equipment operation.)

VII. Items to observe with line equipment

   A. Broken, cracked, or chipped bushings

   B. Oil leaks

   C. Temperature indicators

   D. Operation counter

   E. Lightning arrester gaps

VIII. Line inspection form (Assignment Sheet #1)

   (NOTE: A complete inspection of a distribution system should be made every five to eight years with about 20 percent of the system being inspected each year. A typical line inspection form is included on the following page; however, forms will vary in content between organizations.)

INFORMATION SHEET

Example: Completed line inspection form

LINE 12 E 5

INSPECTOR L J Blow DATE 6-6-78

NOTES
Pole 10 needs to be moved 20 feet south to avoid a wash out - Insulators need to be replaced on poles 3, 9, + 19

POLE NO.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
SIZE	30/5	30/5	35/6	40/5	35/6	30/6	30/6	35/6	35/6	40/5	40/5	35/6	30/6	35/5	30/5	30/6	35/6	35/6	35/5	
CLIMB INSPECT			✓		✓	✓	✓	✓	✓			✓	✓			✓	✓	✓		
HARDWARE	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
KEYS PINS	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
INSULATOR	✓	✓	X	✓	✓	✓	✓	✓	X	✓	✓	✓	✓	✓	✓	✓	✓	✓	X	
FRAMING	A4	VA1	VA1	VA1	VA1	VA1	VA1	VA1	VA1	VA1	VA1	VA1	VA1	VA1	VA1	VA1	VA1	VA1	VA5	
SOUND POLE			✓		✓	✓	✓	✓	✓			✓	✓			✓	✓	✓		
PLUMB & RETAMP										✓										
GUYS TIGHTEN	✓																		✓	
ANCHOR RODS																				
UNDERBUILD																				
FOREIGN LINES																				

ROAD CREEK CANYON Creek washing out near pole 10

TREES CUT FEET

TREES POISONED FEET 110′ between poles 6 + 7 - permission obtained from owner

LINE PATROL
UNIT I

ASSIGNMENT SHEET #1--COMPLETE LINE INSPECTION FORM

Use an existing distribution line to complete the line inspection form below.

LINE ______________________________

INSPECTOR ______________ DATE ________

NOTES

POLE NO.																				
SIZE																				
CLIMB INSPECT																				
HARDWARE																				
KEYS PINS																				
INSULATOR																				
FRAMING																				
SOUND POLE																				
PLUMB & RETAMP																				
GUYS TIGHTEN																				
ANCHOR RODS																				
UNDERBUILD																				
FOREIGN LINES																				

ROAD CREEK CANYON ______________________________

TREES CUT FEET ______________________________

TREES POISONED FEET ______________________________

LINE PATROL
UNIT I

TEST

NAME ______________________________ SCORE ______________

1. List four types of line patrol.

   a. ______________________________

   b. ______________________________

   c. ______________________________

   d. ______________________________

2. Match the types of line patrol on the right to the specific purpose.

   _____a. Compile detailed information on an existing line for a line change such as a line move, a rebuild, or reconductoring

   _____b. Examine and report the condition of each pole, insulator, and conductor and all right-of-ways

   _____c. Determine the cause of a problem such as blinking lights or breaker operations

   _____d. Locate a fault or problem without delay to restore service or to prevent an outage

   1. Regular
   2. Follow-up
   3. Special
   4. Emergency

3. Select from the following list items to observe when patrolling a line.

   _____a. Conductors

   _____b. Guys

   _____c. Woodpecker holes

   _____d. Poles

   _____e. Foreign objects on poles

   _____f. Crossarms

   _____g. Insulators

   _____h. Trees

______i. Line equipment

______j. Kites or kite string

______k. Ground wires

______l. Mobile equipment

______m. Crossings

______n. Washes near poles

______o. Radio interference

______p. Sag

______q. Wildlife

______r. Jumpers

______s. Hardware

______t. Tie wires

______u. Clearances

______v. Construction near line

4. Match the items on the right to the specific conditions to observe when patrolling a line.

______a. Cracks, chips, or blackening

______b. Leaning, washed out, or graded out

______c. Broken anchor rod or stretched conductor

______d. Loose connector at neutral or staples not driven into pole

______e. Burned spots; broken or frayed strands

______f. Loose nuts, washers, or connectors

______g. Near enough to blow into conductor or break off and fall onto conductor

______h. Cracks, splits, or loose hardware

______i. Slack enough to blow into pole or equipment

1. Guys
2. Crossarms
3. Conductors
4. Ground wires
5. Crossings
6. Trees
7. Poles
8. Insulators
9. Sag
10. Jumpers
11. Hardware

_____j. Insufficient separation of conductors

_____k. Insufficient clearance over roads or from other utilities

5. List three methods of line patrol.

a. ______________________________

b. ______________________________

c. ______________________________

6. Select from the following list the requirements of a patroller by placing an "X" in the blanks.

_____a. Make a written report of the line conditions observed

_____b. Follow up on reported conditions to see that repairs are made

_____c. Observe all parts of line being patrolled

_____d. Distinguish between hazardous and nonhazardous conditions

_____e. Make a routine voltage check along the line

_____f. Make a list of materials and equipment needed to make repairs

7. List five items to observe with line equipment.

a. ______________________________

b. ______________________________

c. ______________________________

d. ______________________________

e. ______________________________

8. Complete a line inspection form.

(NOTE: If this activity has not been accomplished prior to the test, ask your instructor when it should be completed.)

LINE PATROL
UNIT I

ANSWERS TO TEST

1. List four types of line patrol.

   a. Regular

   b. Emergency

   c. Specific

   d. Follow-up

2. Match the types of line patrol on the right to the specific purpose.

3	a. Compile detailed information on an existing line for a line change such as a line move, a rebuild, or reconductoring	1.	Regular
1	b. Examine and report the condition of each pole, insulator, and conductor and all right-of-ways	2.	Follow-up
2	c. Determine the cause of a problem such as blinking lights or breaker operations	3.	Special
4	d. Locate a fault or problem without delay to restore service or to prevent an outage	4.	Emergency

3. Select from the following list items to observe when patrolling a line.

   X a. Conductors

   X b. Guys

   X c. Woodpecker holes

   X d. Poles

   X e. Foreign objects on poles

   X f. Crossarms

   X g. Insulators

   X h. Trees

   X i. Line equipment

   X j. Kites or kite string

X k. Ground wires

______ l. Mobile equipment

X m. Crossings

X n. Washes near poles

X o. Radio interference

X p. Sag

______ q. Wildlife

X r. Jumpers

X s. Hardware

X t. Tie wires

X u. Clearances

X v. Construction near line

4. Match the items on the right to the specific conditions to observe when patrolling a line.

8 a. Cracks, chips, or blackening

7 b. Leaning, washed out, or graded out

1 c. Broken anchor rod or stretched conductor

4 d. Loose connector at neutral or staples not driven into pole

3 e. Burned spots; broken or frayed strands

11 f. Loose nuts, washers, or connectors

6 g. Near enough to blow into conductor or break off and fall onto conductor

2 h. Cracks, splits, or loose hardware

10 i. Slack enough to blow into pole or equipment

9 j. Insufficient separation of conductors

5 k. Insufficient clearance over roads or from other utilities

1. Guys
2. Crossarms
3. Conductors
4. Ground wires
5. Crossings
6. Trees
7. Poles
8. Insulators
9. Sag
10. Jumpers
11. Hardware

5. List three methods of line patrol.

   a. Foot

   b. Vehicle

   c. Aircraft

6. Select from the following list the requirements of a patroller by placing an "X" in the blanks.

   ___X___ a. Make a written report of the line conditions observed

   ___X___ b. Follow up on reported conditions to see that repairs are made

   ___X___ c. Observe all parts of line being patrolled

   ___X___ d. Distinguish between hazardous and nonhazardous conditions

   _______ e. Make a routine voltage check along the line

   ___X___ f. Make a list of materials and equipment needed to make repairs

7. List five items to observe with line equipment.

   a. Broken, cracked, or chipped bushings

   b. Oil leaks

   c. Temperature indicators

   d. Operation counter

   e. Lightning arrester gaps

8. Complete a line inspection form.

   (NOTE: This activity will be evaluated to the satisfaction of the instructor.)

ELECTRICAL EQUIPMENT
UNIT II

UNIT OBJECTIVE

After completion of this unit, the student should be able to put a voltage regulator in or out of service with safety. The student should be able to disconnect, transport, and store capacitors safely. The student should be able to protect line equipment by installing oprotective equipment. This knowledge will be evidenced by scoring 85 percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms used with electrical equipment to the correct definitions.
2. Match electrical equipment to the specific uses.
3. Arrange in order the steps to follow when connecting a voltage regulator to a three-phase line.
4. Arrange in order steps to follow when placing a voltage regulator in service.
5. State the procedure for setting voltage regulator time delays.
6. State the procedure for taking a voltage regulator out of service.
7. List precautions to observe with voltage regulators.
8. List precautions to observe with capacitors.
9. Select from a list the benefits of capacitor application.
10. Name equipment that should be protected by lightning arresters.
11. State the method of coordinating reclosers with other reclosers.
12. List precautions to observe when installing sectionalizers.
13. Select from a list factors to consider when coordinating reclosers and fuses.

ELECTRICAL EQUIPMENT
UNIT II

SUGGESTED ACTIVITIES

I. Suggested activities for instructor:

   A. Provide student with objective sheet.

   B. Provide student with information and assignment sheets.

   C. Make transparencies.

   D. Discuss unit and specific objectives.

   E. Discuss information and assignment sheets.

   F. Demonstrate the procedure for setting the voltage, time delay, and the line drop compensation on a voltage regulator.

   G. Show films and other supplemental material on electrical equipment.

   H. Give test.

II. Unit references:

   A. Rural Electrification Administration. *Voltage Regulator Application.* REA Bulletin 169-27. Washington, D.C.: U.S. Department of Agriculture, January 1973.

   B. Rural Electrification Administration. *The Application of Shunt Capacitors to the Rural Electric System.* REA Bulletin 169-1. Washington, D.C.: U.S. Department of Agriculture, December 1972.

ELECTRICAL EQUIPMENT
UNIT II

INFORMATION SHEET

I. Terms and definitions

A. Bandwidth--Area above and below the voltage regulator setting within which the voltage may fluctuate without causing the regulator to operate

B. Line drop compensator--Device which allows a voltage regulator to hold a desired voltage at some point along the line

C. Range of regulation--Travel of the tap changer in either direction

D. Time delay--Device which allows a predetermined response time for the regulator

E. Voltage level setting--Control for desired voltage delivered to the consumer's meter

F. Short circuit strength--Ability of a regulator to withstand 40 times the full-load current rating for 0.8 seconds without damage

G. Induction--Process by which an electrical conductor becomes energized when in a magnetic field or flux

H. Inductor--Part of electrical equipment which acts upon another part or itself by induction

I. Inductance--Element in a circuit which opposes a change in the existing current

J. Capacitance--Storage of electrical energy

K. Reactance--Opposition to alternating current caused by inductance, capacitance, or both in any circuit

L. Inductive reactance--Opposition to alternating current caused by a coil

M. VAR (volt-ampere reactance)--Unit of measurement of power produced by a capacitor

II. Electrical equipment and uses

A. Voltage regulator--Maintains a system voltage level within prescribed limits (Transparency 1)

B. Capacitor--Offsets the current losses and voltage drop caused by induction

INFORMATION SHEET

C. Oil circuit recloser--Opens a circuit in case of a fault and operates four times before it locks open on a fault that does not clear

D. Sectionalizer--Is used in conjunction with an oil circuit recloser to open a circuit on the second or third operation of the recloser

E. Fused cutout--Is used in conjunction with an oil circuit recloser or a sectionalizer to clear a fault on a system

F. Lightning arrester--Provides a low resistance path for high voltage surges and provides a high resistance path to current (Transparency 1)

III. Connecting voltage regulator to three-phase line (Transparency 2, Assignment Sheet #1)

A. Connect jumper to source side switch

B. Connect lightning arrester to source side switch

C. Connect source side switch to "S" bushing

D. Connect "L" bushing to load side switch

E. Connect lightning arrester to load side switch

F. Connect load side switch to load line

G. Ground "SL" bushing to tank and system neutral

IV. Steps to follow when placing a voltage regulator in service (Transparency 1)

A. Install regulator with source and load side switches open and bypass switch closed

(NOTE: Do not energize the regulator.)

B. Check the tank and "SL" bushing for solid grounds

C. Energize the regulator by closing the source side switch only

D. Turn the potential power switch to On

E. Set the regulator control knob to Lower

F. Let the regulator stop at 16 Lower

INFORMATION SHEET

G. Move the control knob to Raise

H. Count the steps as the regulator position indicator moves to the Neutral position

(NOTE: On a thirty-two step regulator, this should be sixteen steps.)

I. Let the regulator continue to 16 Raise

J. Set control knob to Lower and count the steps as the regulator position indicator moves toward the Neutral position

K. Stop the regulator in the Neutral position

(NOTE: Counting the steps in both directions insures that the regulator is in the Neutral position when the indicator shows it to be.)

L. Turn the potential power switch and the control knob to the Off position

M. Set the voltage level knobs to the desired voltage

N. Close the load side switch and open the bypass switch

(CAUTION. Serious damage and possible injury will result if a regulator is put into service without being set in the Neutral position before the load side switch is closed and the bypass switch is opened.)

O. Set the control knob on Automatic

P. Check the output voltage with a calibrated voltmeter

V. Procedure for setting voltage regulator time delays--The regulator which is farthest from the power source should be set with the longest time delay

VI. Procedure for taking a voltage regulator out of service

A. Place the regulator in the Neutral position

(CAUTION: If the regulator has malfunctioned and cannot be moved to the Neutral position, the line should be de-energized to take the regulator out of service.)

B. Turn the control and power switches to the Off position

C. Close the bypass switch and open the source and load switches

INFORMATION SHEET

VII. Precautions to observe with voltage regulators

A. Size the regulator to the load requirements

(NOTE: A regulator which is too small will soon be damaged by overload.)

B. Set the line drop compensator according to engineering recommendations

C. Set the bandwidth at the REA recommended setting of two volts

D. Set the shortest time delay on the regulator closest to the source

E. Do not bypass the regulator unless the regulator is in the Neutral position

VIII. Precautions to observe with capacitors

(CAUTION: A capacitor may retain a hazardous charge for an indefinite time after being disconnected.)

A. Wait at least five minutes after disconnecting a capacitor before grounding it

B. Keep capacitors short-circuited when stored or transported

C. Dispose of faulty capacitors by sending to disposal company recommended by the manufacturer

D. Do not re-fuse a capacitor if the case is distorted

IX. Benefits of capacitor application

A. Improves power factor

B. Reduces costs charged by power suppliers for poor power factor

C. Improves voltage level

D. Reduces line and transformer losses

E. Improves efficiency of substation transformer

X. Equipment that should be protected by lightning arresters

A. Transformers

B. Capacitors

INFORMATION SHEET

C. Regulators

D. Reclosers

E. Sectionalizers

F. Fuses

G. Metering equipment

H. Underground installations

XI. Method of coordinating a recloser with another recloser (Transparency 3)

A. Select reclosers with the same time-current characteristics

(NOTE: Reclosers of the same make, type, and operation sequence will simplify recloser coordination.)

B. Install reclosers from the source, dropping to the next smaller size toward the end of the line

Example: 100 ampere-rated recloser at the substation, 70 ampere-rated recloser three miles from the substation, 50 ampere-rated recloser seven miles from the substation, 35 ampere-rated recloser ten miles from the substation

C. Drop the recloser two sizes when installing on taps or branch circuits

Example: Recloser installed on the taps between the substation (100 ampere OCR) and the next 70 ampere OCR may be 50 ampere rated

(NOTE: Any recloser should have a generous margin between the interrupting rating and the available short-circuit current at the location of installation.)

XII. Precautions to observe when installing sectionalizers

A. Size the sectionalizer to its back-up recloser

Example: 100 ampere recloser and 100 ampere sectionalizer

B. Install sectionalizers on taps or branch circuits only

(NOTE: Sectionalizers have no inherent capacity to interrupt fault currents and should never be placed between reclosers. A sectionalizer will open on the first or second operation of the recloser during the open-circuit time of the recloser.)

C. Do not install sectionalizers and line fuses in series

INFORMATION SHEET

XIII. Factors to consider when coordinating reclosers and fuses

A. Set recloser for a combination of fast and time delay operations

(NOTE: The recloser is usually set for two fast and two delay operations.)

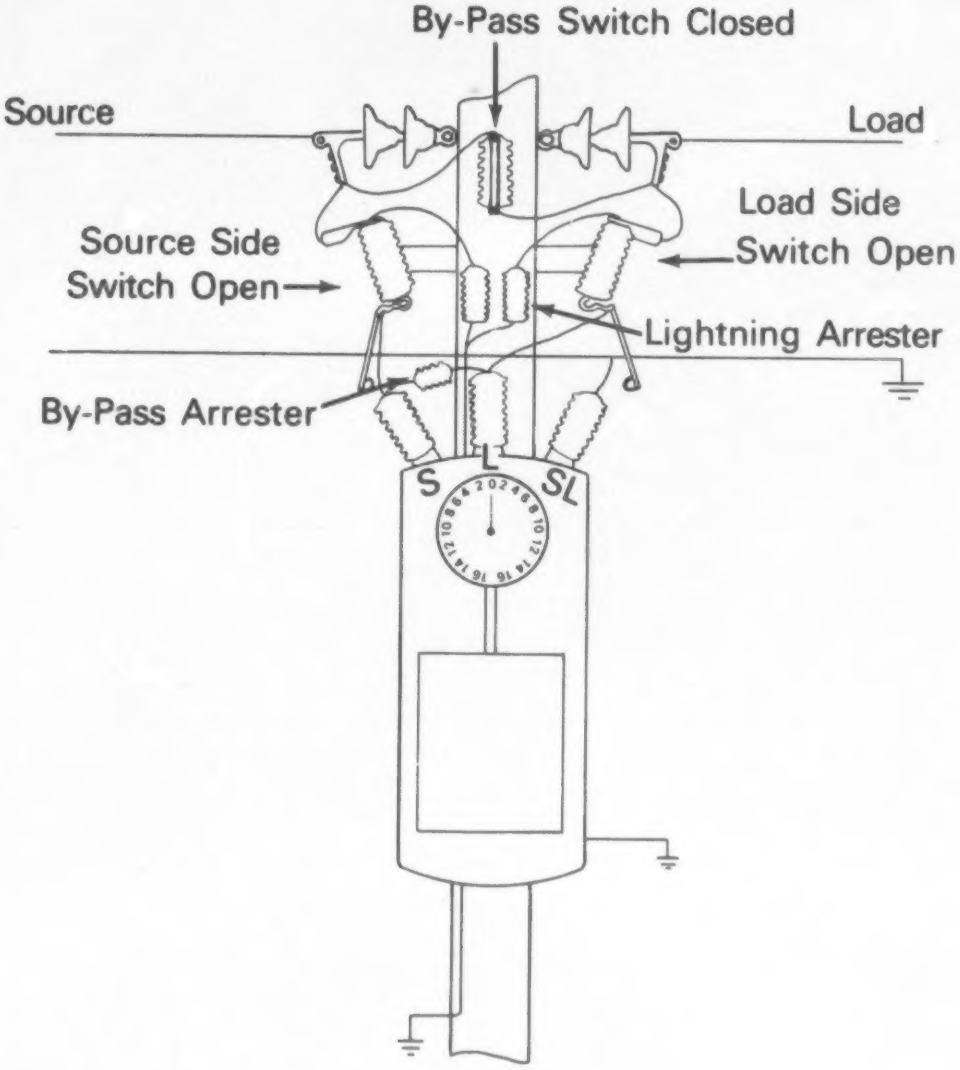
B. Select a recloser with a coil small enough to detect minimum fault current on the line protected by the fuse

C. Select fuse with a time-current characteristic as close as possible to the recloser time-current characteristic

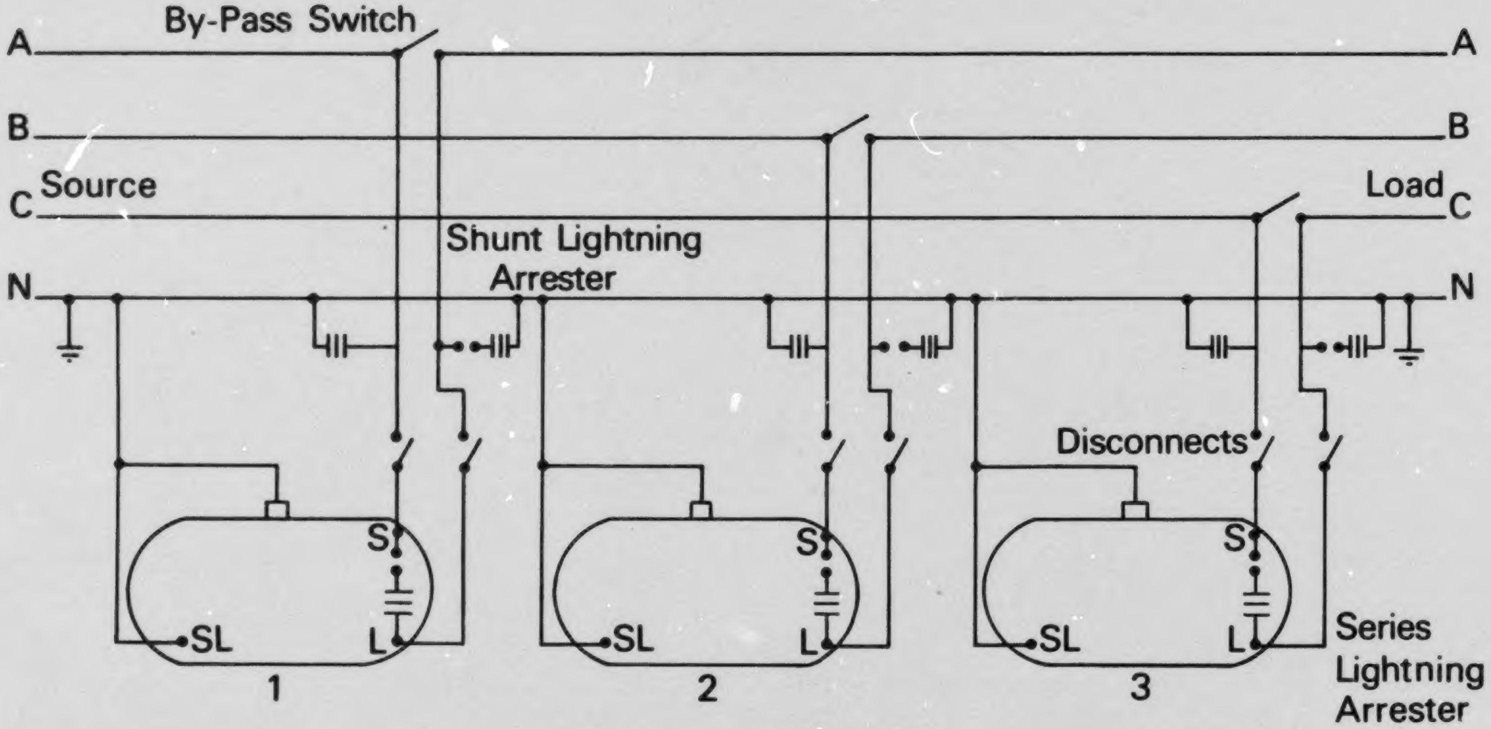
(NOTE: Use the manufacturer's fuse curve scale to calculate the fuse characteristics.)

D. Select a fuse size with minimum melting and maximum clearing time-current characteristics which lie between the fast and time delay opening of the recloser

Voltage Regulator



Voltage Regulator Connections



Three-Phase, 4-Wire, Multi-Grounded
Circuit Using Three Regulators.

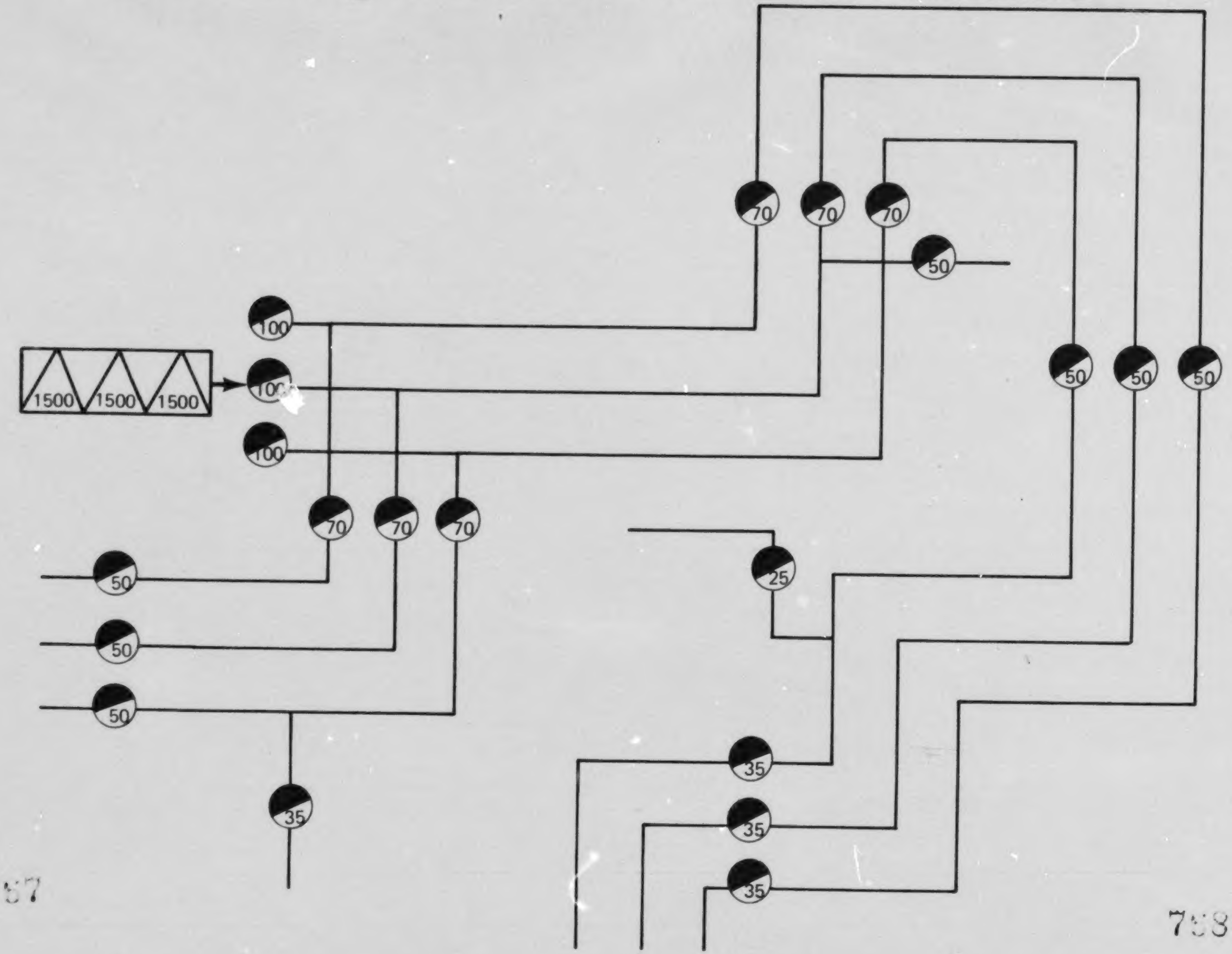
735

TM 2

736

PLT - 31-F

Coordinating Reclosers With Other Reclosers



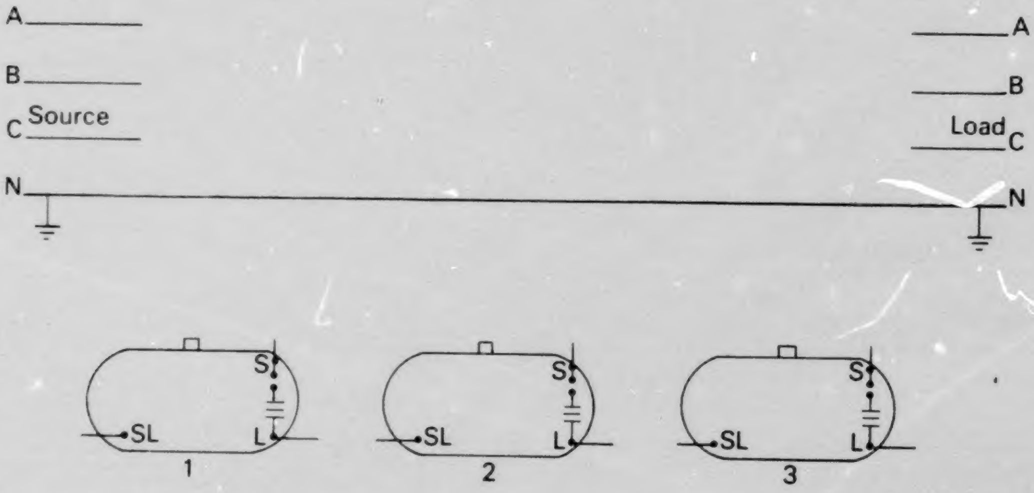
757

758

ELECTRICAL EQUIPMENT
UNIT II

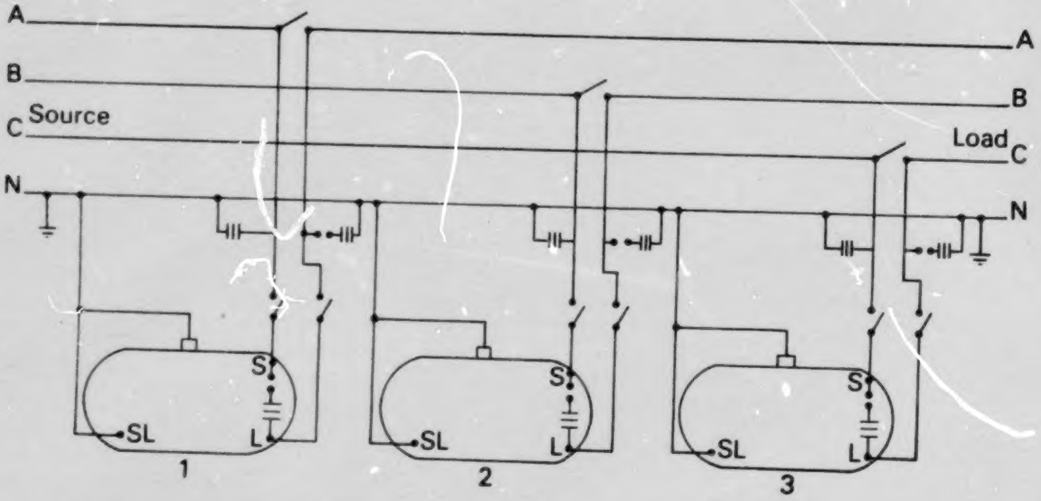
ASSIGNMENT SHEET #1--CONNECT VOLTAGE REGULATORS TO A THREE-PHASE LINE

Draw lines to connect the three regulators to the three-phase line. Include all switches, grounds, and lightning arresters.



ELECTRICAL EQUIPMENT
UNIT II

ANSWERS TO ASSIGNMENT SHEET



ELECTRICAL EQUIPMENT
UNIT II

TEST

NAME ______________________________ SCORE ____________________

1. Match the terms on the right to the correct definitions.

_____a. Area above and below the voltage regulator setting within which the voltage may fluctuate without causing the regulator to operate

_____b. Device which allows a voltage regulator to hold a desired voltage at some point along the line

_____c. Travel of the tap changer in either direction

_____d. Device which allows a predetermined response time for the regulator

_____e. Control for desired voltage delivered to the consumer's meter

_____f. Ability of a regulator to withstand 40 times the full-load current rating for 0.8 seconds without damage

_____g. Opposition to alternating current caused by a coil

_____h. Process by which an electrical conductor becomes energized when in a magnetic field or flux

_____i. Part of electrical equipment which acts upon another part or itself by induction

_____j. Opposition to alternating current caused by inductance, capacitance, or both in any circuit

_____k. Element in a circuit which opposes a change in the existing current

1. Time delay
2. Voltage level setting
3. Short circuit strength
4. Bandwidth
5. Range of regulation
6. Line drop compensator
7. Inductive reactance
8. Inductor
9. Inductance
10. Capacitance
11. Induction
12. Reactance
13. VAR (Volt-ampere reactance)

______l. Storage of electrical energy

______m. Unit of measurement of power produced by a capacitor

2. Match the electrical equipment on the right to the correct uses.

______a. Maintains a system voltage level within prescribed limits

______b. Offsets the current losses and voltage drop caused by induction

______c. Opens a circuit in case of a fault and operates four times before it locks open on a fault that does not clear

______d. Is used in conjunction with an oil circuit recloser or a sectionalizer to clear a fault on a system

______e. Is used in conjunction with an oil circuit recloser to open a circuit on the second or third operation of the recloser

______f. Provides a low resistance path for high voltage surges and provides a high resistance path to current

1. Fused cutout
2. Oil circuit recloser
3. Sectionalizer
4. Voltage regulator
5. Lightning arrester
6. Capacitor

3. Arrange in the proper order the steps to follow when connecting a voltage regulator to a three-phase line.

______a. Connect "L" bushing to load side switch

______b. Ground "SL" bushing to tank and system neutral

______c. Connect source side switch to "S" bushing

______d. Connect jumper to source side switch

______e. Connect lightning arrester to load side switch

______f. Connect load side switch to load line

______g. Connect lightning arrester to source side switch

4. Arrange in the proper order the following steps for placing a voltage regulator in service by placing a "1" before the first step, a "2" before the second step, and so on.

_____a. Close the load side switch and open the bypass switch

_____b. Check the tank and "SL" bushing for solid grounds

_____c. Install regulator with source and load side switches open and bypass switch closed

_____d. Stop the regulator in the Neutral position

_____e. Set the control knob on Automatic

_____f. Count the steps as the regulator position indicator moves to the Neutral position

_____g. Turn the potential power switch to On

_____h. Energize the regulator by closing the source side switch only

_____i. Set the voltage level knobs to the desired voltage

_____j. Set control knob to Lower and count the steps as the regulator position indicator moves toward the Neutral position

_____k. Set the regulator control knob to Lower

_____l. Let the regulator stop at 16 Lower

_____m. Move the control knob to Raise

_____n. Let the regulator continue to 16 Raise

_____o. Turn the potential power switch and the control knob to the Off position

_____p. Check the output voltage with a calibrated voltmeter

5. State the procedure for setting voltage regulator time delays.

____

____

____

6. State the procedure for taking a voltage regulator out of service.

a. ____

____

b. ____

____

c. ______________________________

____

7. List four precautions to observe with voltage regulators.

a. ______________________________

____

b. ______________________________

____

c. ______________________________

____

d. ______________________________

____

8. List four precautions to observe with capacitors.

a. ______________________________

____

____

b. ______________________________

____

____

c. ______________________________

____

____

d. ______________________________

____

____

9. Select from the following list the benefits of capacitor application by placing an "X" in the blanks.

______a. Reduces line and transformer losses

______b. Improves voltage level

______c. Increases power flow

______d. Improves efficiency of substation transformer

______e. Reduces costs charged by power suppliers for poor power factor

10. Name seven pieces of equipment that should be protected by lightning arresters.

a. ______________________________

b. ______________________________

c. ______________________________

d. ______________________________

e. ______________________________

f. ______________________________

g. ______________________________

11. State the method of coordinating a recloser with another recloser.

a. ______________________________

____

____

b. ______________________________

____

____

c. ______________________________

____

____

12. List three precautions to observe when installing sectionalizers.

a. ______________________________

____

b. ______________________________

____

c. ______________________________

____

13. Select from the following list factors to consider when coordinating reclosers and fuses.

______a. Set recloser for two operations only

______b. Select a fuse size with minimum melting and maximum clearing time-current characteristics which lie between the fast and time delay opening of the recloser

______c. Select fuse with a time-current characteristic as close as possible to the recloser time-current characteristic

______d. Select recloser with a coil small enough to detect minimum fault current on the line protected by the fuse

______e. Set recloser for a combination of fast and time delay operations

ELECTRICAL EQUIPMENT
UNIT II

ANSWERS TO TEST

1. Match the terms on the right to the correct definitions.

4 a. Area above and below the voltage regulator setting within which the voltage may fluctuate without causing the regulator to operate

6 b. Device which allows a voltage regulator to hold a desired voltage at some point along the line

5 c. Travel of the tap changer in either direction

1 d. Device which allows a predetermined response time for the regulator

2 e. Control for desired voltage delivered to the consumer's meter

3 f. Ability of a regulator to withstand 40 times the full-load current rating for 0.8 seconds without damage

7 g. Opposition to alternating current caused by a coil

11 h. Process by which an electrical conductor becomes energized when in a magnetic field or flux

8 i. Part of electrical equipment which acts upon another part or itself by induction

12 j. Opposition to alternating current caused by inductance, capacitance, or both in any circuit

9 k. Element in a circuit which opposes a change in the existing current

1. Time delay
2. Voltage level setting
3. Short circuit strength
4. Bandwidth
5. Range of regulation
6. Line drop compensator
7. Inductive reactance
8. Inductor
9. Inductance
10. Capacitance
11. Induction
12. Reactance
13. VAR (volt-ampere reactance)

__10__ l. Storage of electrical energy

__13__ m. Unit of measurement of power produced by a capacitor

2. Match the electrical equipment on the right to the correct uses.

__4__ a. Maintains a system voltage level within prescribed limits

__6__ b. Offsets the current losses and voltage drop caused by induction

__2__ c. Opens a circuit in case of a fault and operates four times before it locks open on a fault that does not clear

__1__ d. Is used in conjunction with an oil circuit recloser or a sectionalizer to clear a fault on a system

__3__ e. Is used in conjunction with an oil circuit recloser to open a circuit on the second or third operation of the recloser

__5__ f. Provides a low resistance path for high voltage surges and provides a high resistance path to current

1. Fused cutout
2. Oil circuit recloser
3. Sectionalizer
4. Voltage regulator
5. Lightning arrester
6. Capacitor

3. Arrange in the proper order the steps to follow when connecting a voltage regulator to a three-phase line.

__4__ a. Connect "L" bushing to load side switch

__7__ b. Ground "SL" bushing to tank and system neutral

__3__ c. Connect source side switch to "S" bushing

__1__ d. Connect jumper to source side switch

__5__ e. Connect lightning arrester to load side switch

__6__ f. Connect load side switch to load line

__2__ g. Connect lightning arrester to source side switch

4. Arrange in the proper order the following steps for placing a voltage regulator in service by placing a "1" before the first step, a "2" before the second step, and so on.

14 a. Close the load side switch and open the bypass switch

2 b. Check the tank and "SL" bushing for solid grounds

1 c. Install regulator with source and load side switches open and bypass switch closed

11 d. Stop the regulator in the Neutral position

15 e. Set the control knob on Automatic

8 f. Count the steps as the regulator position indicator moves to the Neutral position

4 g. Turn the potential power switch to On

3 h. Energize the regulator by closing the source side switch only

13 i. Set the voltage level knobs to the desired voltage

10 j. Set control knob to Lower and count the steps as the regulator position indicator moves toward the Neutral position

5 k. Set the regulator control knob to Lower

6 l. Let the regulator stop at 16 Lower

7 m. Move the control knob to Raise

9 n. Let the regulator continue to 16 Raise

12 o. Turn the potential power switch and the control knob to the Off position

16 p. Check the output voltage with a calibrated voltmeter

5. State the procedure for setting voltage regulator time delays.

The regulator which is farthest from the power source should be set with the longest time delay

6. State the procedure for taking a voltage regulator out of service.

a. Place the regulator in the Neutral position

b. Turn the control and power switches to the Off position

c. Close the bypass switch and open the source and load switches

7. List four precautions to observe with voltage regulators.

   (NOTE: Any four of the following precautions are acceptable.)

   a. Size the regulator to the load requirements

   b. Set the line drop compensator according to engineering recommendations

   c. Set the bandwidth at the REA recommended setting of two volts

   d. Set the shortest time delay on the regulator closest to the source

   e. Do not bypass the regulator unless the regulator is in the Neutral position

8. List four precautions to observe with capacitors.

   a. Wait at least five minutes after disconnecting a capacitor before grounding it

   b. Keep capacitors short-circuited when stored or transported

   c. Dispose of faulty capacitors by sending to disposal company recommended by the manufacturer

   d. Do not re-fuse a capacitor if the case is distorted

9. Select from the following list the benefits of capacitor application by placing an "X" in the blanks.

   __X__ a. Reduces line and transformer losses

   __X__ b. Improves voltage level

   ______ c. Increases power flow

   __X__ d. Improves efficiency of transformer substation

   __X__ e. Reduces costs charged by power suppliers for poor power factor

10. Name seven pieces of equipment that should be protected by lightning arresters.

   (NOTE: Any seven of the following answers are acceptable.)

   a. Transformers

   b. Capacitors

   c. Regulators

   d. Reclosers

e. Sectionalizers

f. Fuses

g. Metering equipment

h. Underground installations

11. State the method of coordinating a recloser with another recloser.

a. Select reclosers with the same time-current characteristics

b. Install reclosers from the source, dropping to the next smaller size toward the end of the line

c. Drop the recloser two sizes when installing on taps or branch circuits

12. List three precautions to observe when installing sectionalizers.

a. Size the sectionalizer to its back-up recloser

b. Install sectionalizers on taps or branch circuits only

c. Do not install sectionalizers and line fuses in series

13. Select from the following list factors to consider when coordinating reclosers and fuses.

______ a. Set recloser for two operations only

__X__ b. Select a fuse size with minimum melting and maximum clearing time-current characteristics which lie between the fast and time delay opening of the recloser

__X__ c. Select fuse with a time-current characteristic as close as possible to the recloser time-current characteristic

__X__ d. Select recloser with a coil small enough to detect minimum fault current on the line protected by the fuse

__X__ e. Set recloser for a combination of fast and time delay operations

WORK PROCEDURES
(HOT LINE, BASKET, HOT STICK)
UNIT III

UNIT OBJECTIVE

After completion of this unit, the student should be able to list elements of hot line maintenance and follow prescribed procedures and requirements for hot line maintenance. The student should be able to change an insulator with hot line tools. This knowledge will be evidenced through demonstration and by scoring 85 percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. List methods of hot line maintenance.
2. Select from a list OSHA requirements for aerial devices.
3. Select from a list rules to observe when working with an aerial device.
4. List elements of hot line maintenance.
5. State the procedure for hot line maintenance from an aerial device.
6. Arrange in order the steps to follow when changing a pole top insulator from a basket.
7. Match various hot line tools to the specific uses.
8. Demonstrate the ability to:
    a. Install a wire tong saddle.
    b. Change an insulator on an energized conductor using hot line tools on an A1 structure.

WORK PROCEDURES
(HOT LINE, BASKET, HOT STICK)
UNIT III

SUGGESTED ACTIVITIES

I. Suggested activities for instructor:

  A. Provide student with objective sheet.

  B. Provide student with information sheet.

  C. Discuss unit and specific objectives.

  D. Discuss information sheet.

  E. Discuss and demonstrate the procedures outlined on the job sheets.

  F. Show films and other supplemental information on hot line maintenance.

  G. Give test.

II. Unit references:

  A. Department of Labor. "OSHA Regulations for Construction: Section 1926.556, Subpart N, Aerial Lifts." *Federal Register*. Vol. 39, no. 122, pt. 11, 1972.

  B. *Hot Sticks*. Centralia, Missouri: A. B. Chance Co., 1974.

  C. Kurtz, Edwin B., and Shoemaker, Thomas M. *The Lineman's and Cableman's Handbook*. 5th ed. New York: McGraw-Hill Book Co., 1976.

WORK PROCEDURES
(HOT LINE, BASKET, HOT STICK)
UNIT III

INFORMATION SHEET

I. Methods of hot line maintenance

  A. Insulated aerial device

  Examples: Basket, bucket, or ladder

  B. Hot line tool

  Examples: Hot stick, cover-up material

II. OSHA requirements for aerial devices

  A. Lift controls shall be tested each day prior to use

  B. Only trained and authorized persons shall operate an aerial device

  C. Load limits of the equipment shall not be exceeded

  D. Controls shall be plainly marked as to their functions

  E. Boom shall be cradled and outriggers shall be in the stowed position before moving vehicle

III. Rules to observe when working with an aerial device

  (NOTE: Inspect the vehicle and aerial device daily.)

  A. Position the device so that no contact will be made between conductors or other equipment

  B. Rubber gloves and rubber sleeves must be worn while working energized primary from an aerial device

  C. Safety hat and suitable clothing shall be worn when working with an aerial device

  D. Transfer to or from a structure and an aerial device shall not be allowed

  E. Climbers shall not be worn when working from an aerial device

  F. No person shall stand directly beneath the work area of an aerial device

  G. An aerial device shall be considered energized at line potential when the boom or basket is in close proximity to an energized conductor

INFORMATION SHEET

H. Tools or equipment shall not be thrown to or from an aerial device

I. The operator of the lower controls shall be on the vehicle or at the same potential as the vehicle

J. Assurance shall be made that the boom or basket is not in contact with an energized conductor before entering or leaving the vehicle

K. Vehicle frame shall be grounded while the basket is in use near high voltage lines

(NOTE: A driven ground rod or system neutral should be used for grounding the vehicle.)

L. A body belt with a securing strap shall be worn while working from an aerial basket

IV. Elements of hot line maintenance

A. Replacing insulators

B. Replacing crossarms

C. Replacing poles

D. Installing armor rods

E. Splicing conductor

F. Cutting double dead end

G. Cutting slack in or out of conductor

H. Tapping a hot line

V. Procedure for hot line maintenance from aerial device

A. Lower or cover the neutral and grounded parts

B. Work on only one conductor at a time

C. Cover and place energized conductors on insulated lifting attachments

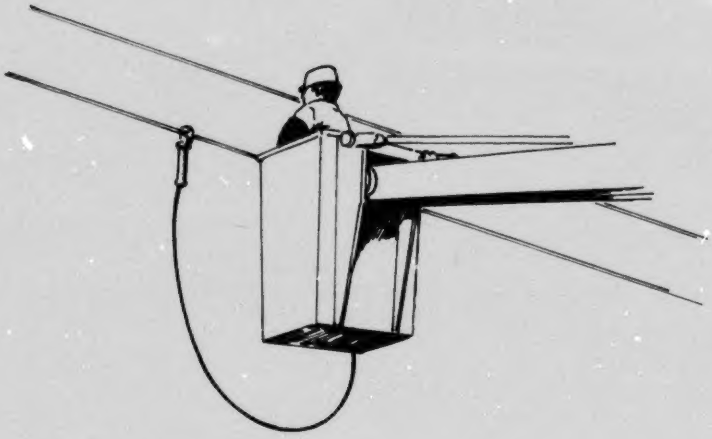
D. Tension energized conductor with rope block or insulated hoist

INFORMATION SHEET

E. Hang handline on structure not on basket

(NOTE: Only high dialectric rope shall be used for handlines that are used in hot line work.)

F. Install insulated jumper on conductor before opening a circuit



VI. Steps to change a pole top insulator from a basket (14,400 volt line)

A. Place warning signs at the work site

B. Position basket truck near the pole

C. Set the vehicle brakes and chock the wheels

D. Check the outrigger footings for stability

E. Clear the area near the vehicle and lower the outriggers

F. Ground the vehicle frame to system neutral or a driven ground

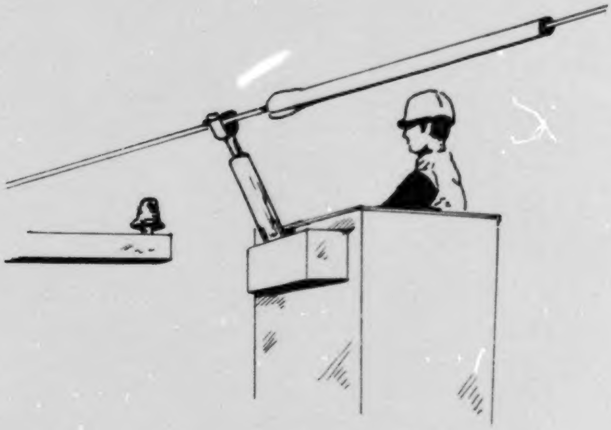
G. Raise basket to neutral position and cover or lower the neutral

H. Elevate the basket to near the pole top and cover the pole top with a rubber blanket

I. Place line hose on the energized conductor near the insulator

INFORMATION SHEET

J. Secure the energized conductor to an insulated attachment



K. Untie the energized conductor

(CAUTION: Use a tie stick or pliers to untie the conductor to avoid puncturing your rubber gloves.)

L. Move conductor away from pole

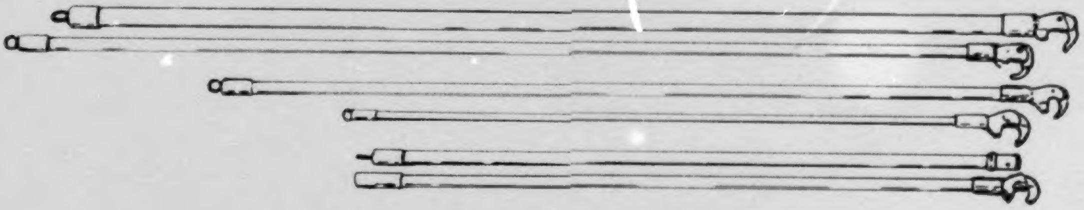
M. Allow line technician on pole to change the insulator

N. Move conductor back to insulator and retie

VII. Hot line tools and their uses

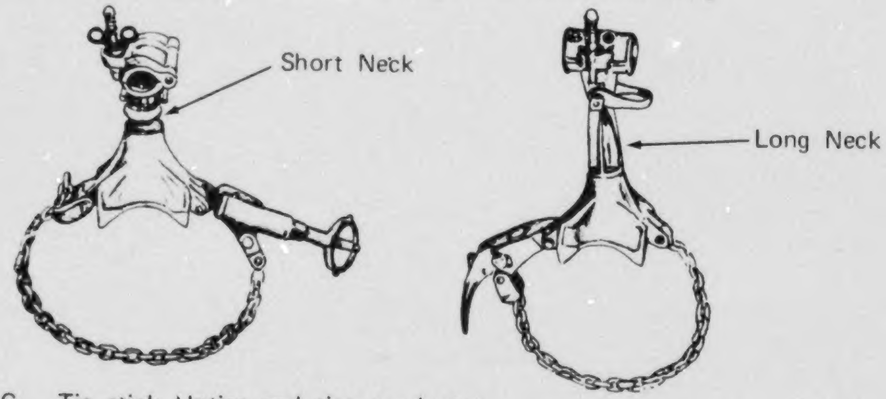
A. Wire tong--Attaches to and holds conductor

(NOTE: Wire tongs are sometimes referred to as *lift sticks* or *holding sticks*.)

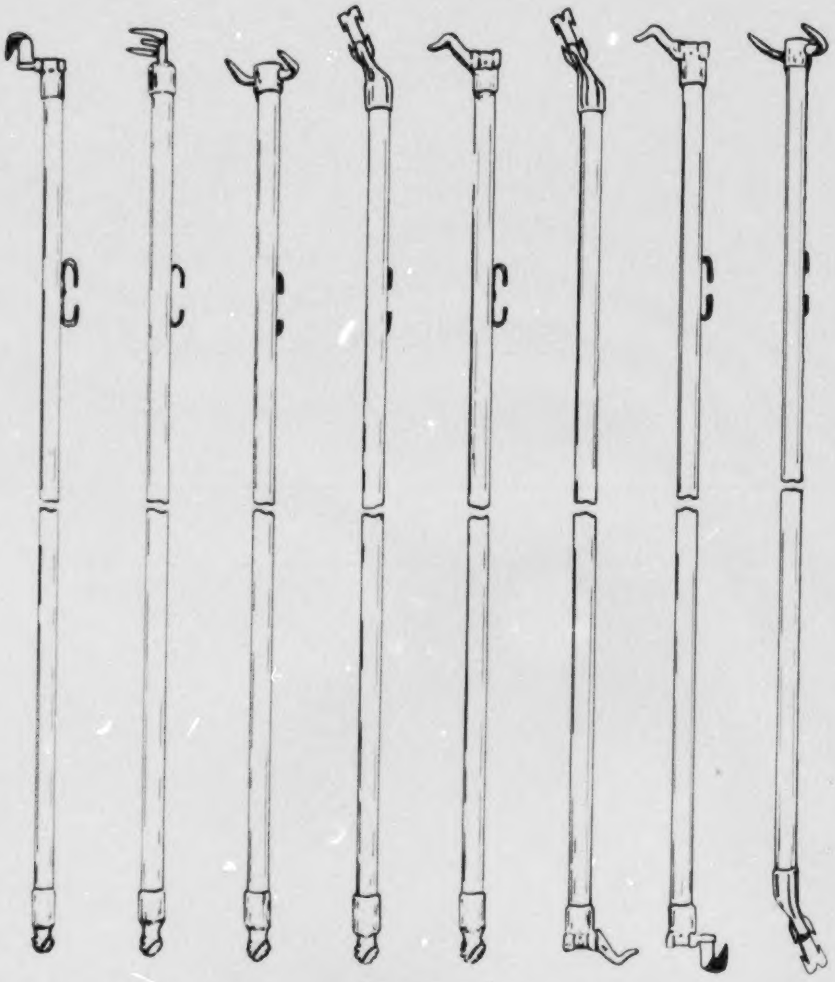


INFORMATION SHEET

B. Wire tong saddle--Secures to pole and holds wire tong

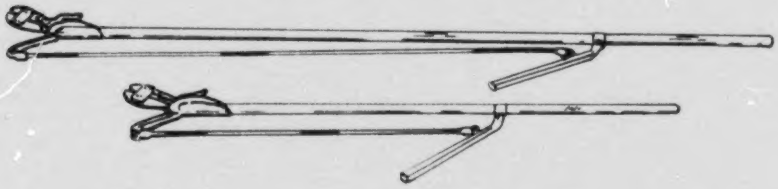


C. Tie stick--Unties and ties conductor

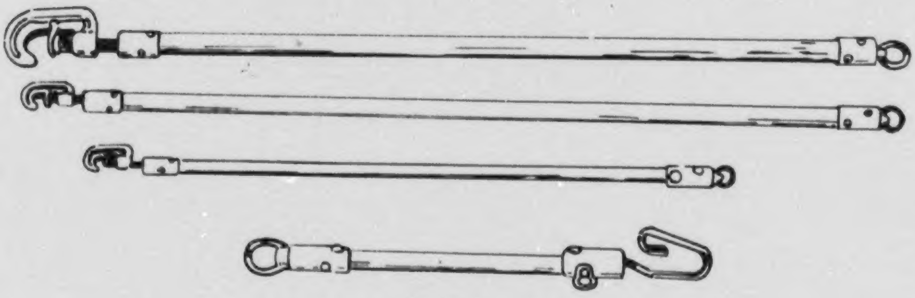


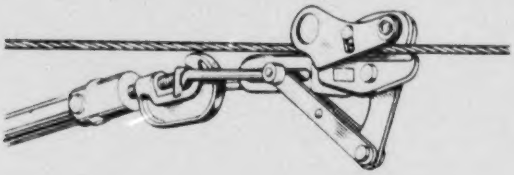
INFORMATION SHEET

D. Wire cutter--Cuts energized conductor and tie wire



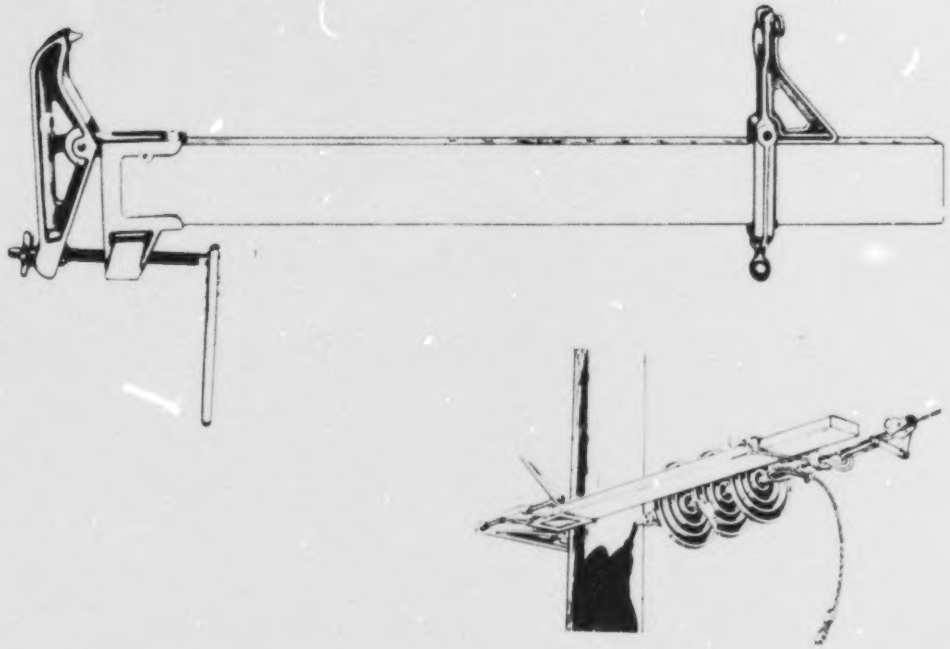
E. Link stick--Holds conductors aside when pole is being relocated



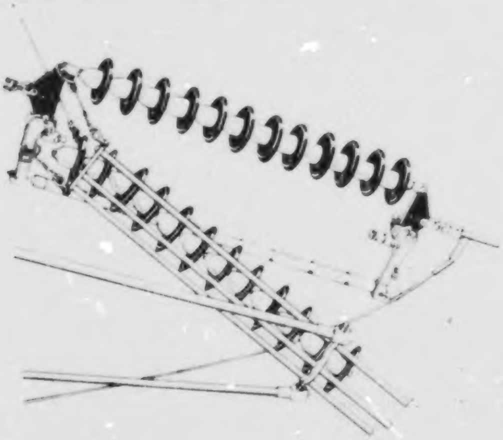


INFORMATION SHEET

F. Rural strain carrier--Supports conductor while suspension insulators are being changed

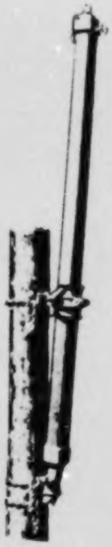


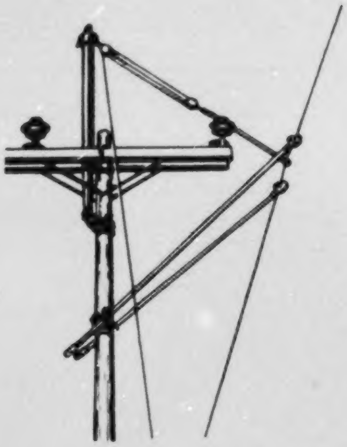
G. Insulator cradle--Lowers and raises insulator string



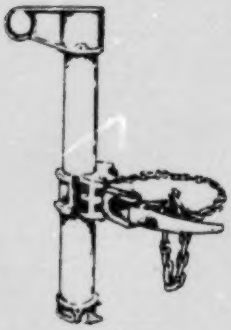
INFORMATION SHEET

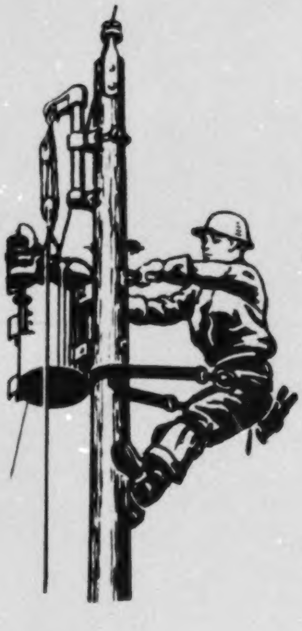
H. Pole gin–Extends a pole to lay out conductor





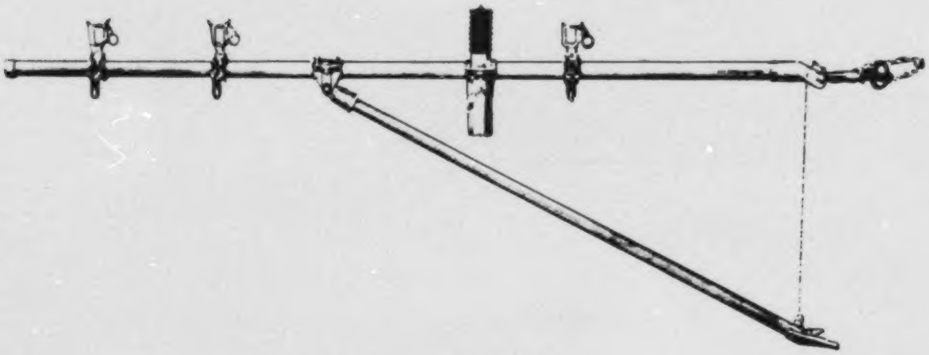
I. Transformer gin--Attachment point for rope blocks to raise and lower transformer

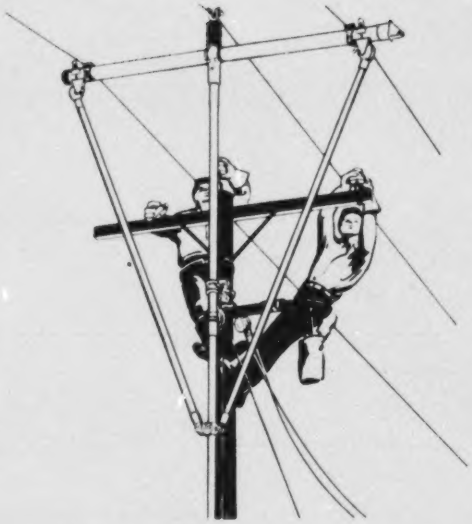




INFORMATION SHEET

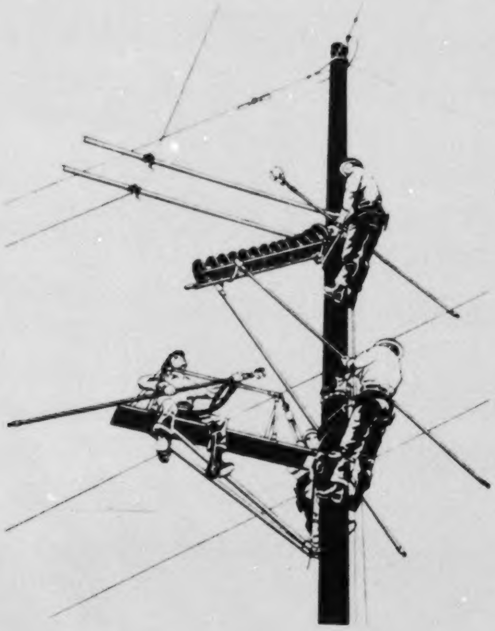
J. Auxiliary arm--Holds conductors out of the way of repairs or is used to raise conductors above work area



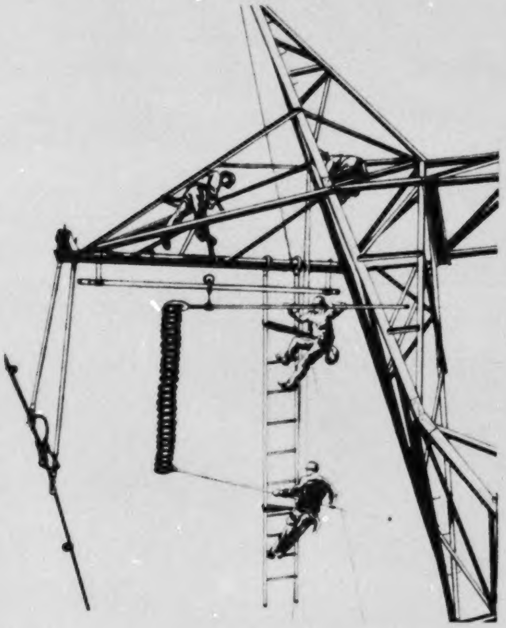


INFORMATION SHEET

K. Universal platform--Supports line technician near work area

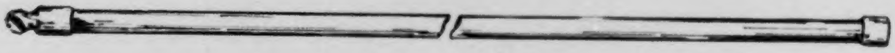


L. Hook ladder--Supports the line technician so the conductor may be reached with wire tong or other hot stick

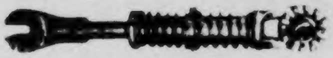


INFORMATION SHEET

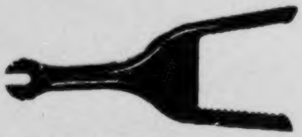
M. Universal hot stick--Attaches to various tools which enable the line technician to tighten or remove clamps, connectors, bolts, and cotter keys



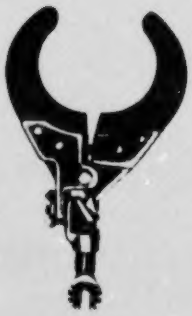
Universal Hot Stick



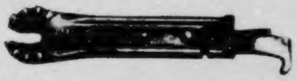
Knocker



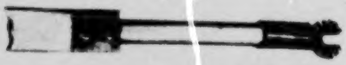
Ball-Socket Adjuster



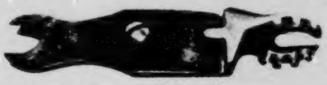
Adjustable Insulator Fork



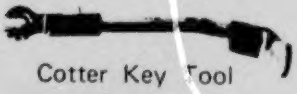
Cotter Key Tool



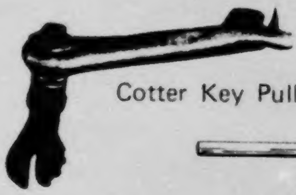
Cotter Key Tool



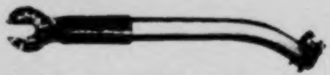
Bolt Holder



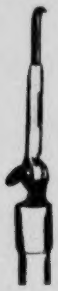
Cotter Key Tool



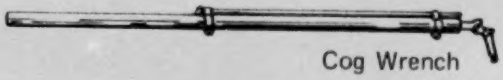
Cotter Key Puller



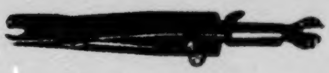
Cotter Key Holder



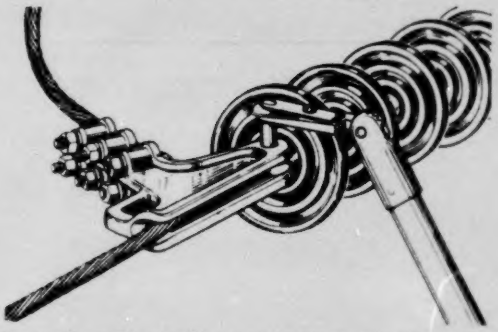
Cotter Key Remover



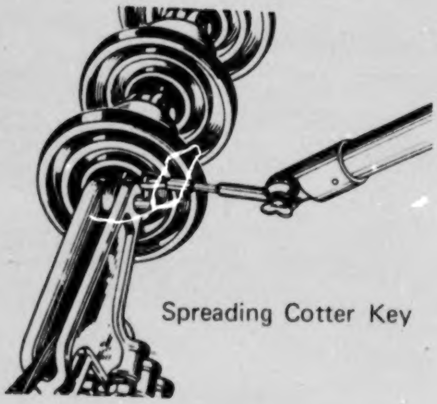
Cog Wrench



Clevis Pin Installer



Inserting Clevis Pin With Bolt Holder Tool



Spreading Cotter Key

WORK PROCEDURES
(HOT LINE, BASKET, HOT STICK)
UNIT III

JOB SHEET #1--INSTALL A WIRE TONG SADDLE

I. Tools and equipment

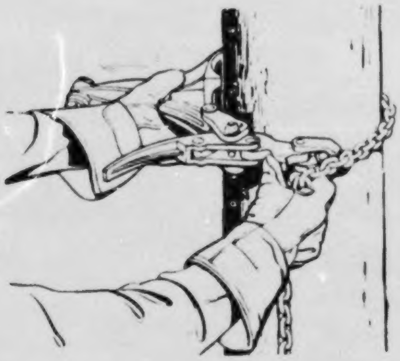
  A. Pole, 10 to 12 feet in height

  B. Wire tong saddle

II. Procedure

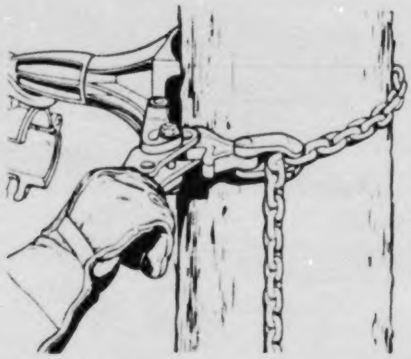
  A. Hold saddle in place with chain around the pole (Figure 1)

FIGURE 1



  B. Hook chain into securing lever hook and push securing lever toward the pole (Figure 2)

FIGURE 2



WORK PROCEDURES
(HOT LINE, BASKET, HOT STICK)
UNIT III

JOB SHEET #2--CHANGE AN INSULATOR ON AN ENERGIZED CONDUCTOR USING HOT LINE TOOLS ON AN A1 STRUCTURE

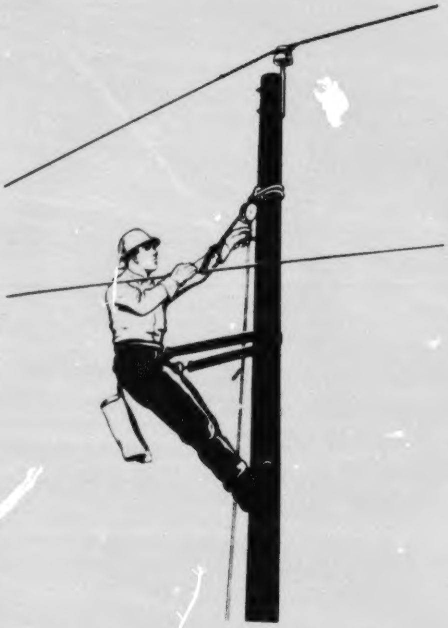
I. Tools and materials

- A. Handline
- B. Rope blocks
- C. Tie stick
- D. Wire cutter
- E. Wire tong
- F. Wire tong extension
- G. Wire tong saddles, 2
- H. Pole top insulator
- I. Tie wire

II. Procedure

- A. Disengage and lower the neutral (Figure 1)

FIGURE 1

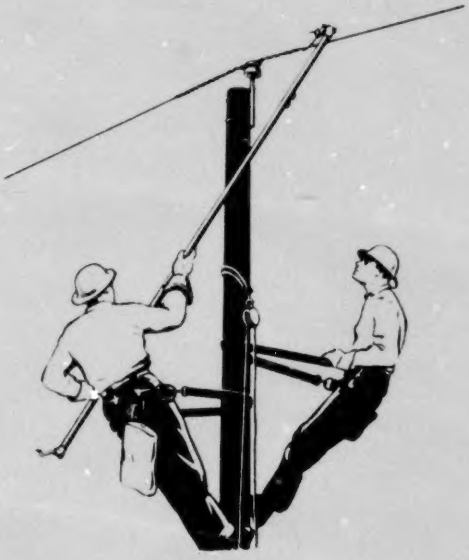


JOB SHEET #2

B. Untie one side of tie wire with tie stick (Figure 2)

(NOTE: Check the tie wire on both sides of the insulator to be sure the tie is not broken before the conductor is untied.)

FIGURE 2

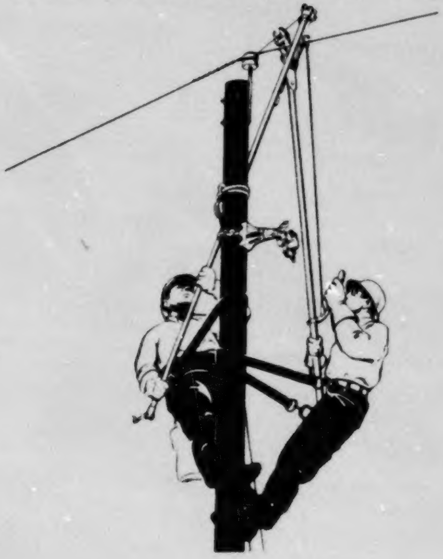


C. Install two wire tong saddles (Figure 3)

1. Install top saddle near the neutral position
2. Install bottom saddle four feet from bottom of wire tong

(NOTE: Keep ends of tie wire clear of hardware and pole.)

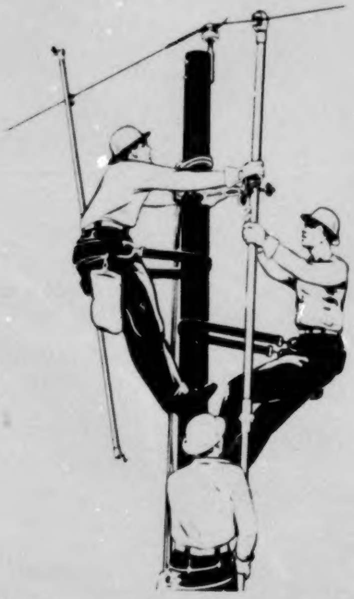
FIGURE 3



JOB SHEET #2

D. Install wire tong and secure to tong saddles by tightening clamps on the saddles (Figure 4)

FIGURE 4



E. Remove the remaining side of the tie wire (Figure 5)

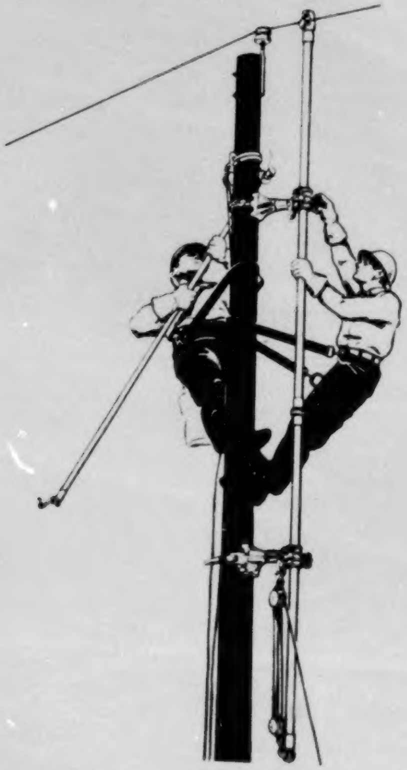
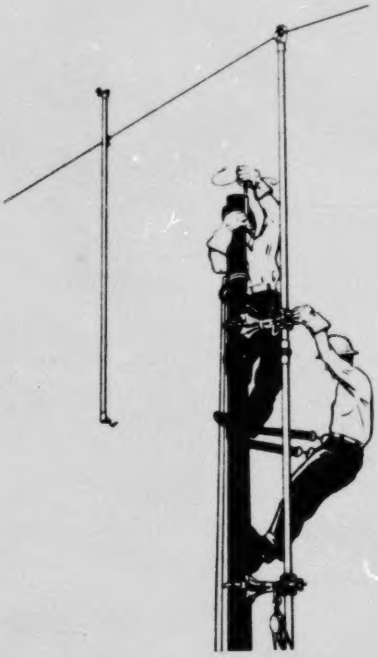


FIGURE 5

JOB SHEET #2

F. Raise the conductor with the wire tong and rope blocks attached to bottom saddle and to bottom end of wire tong; tighten saddle clamps onto wire tong (Figure 6)

FIGURE 6



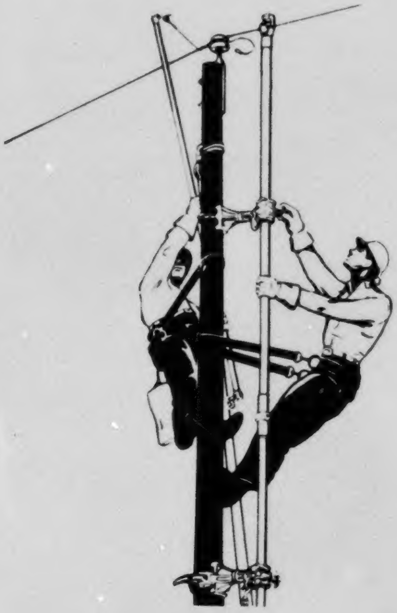
G. Remove old insulator and replace with new insulator with hot line tie attached; align the insulator groove with the conductor

H. Lower the conductor to the groove of the insulator and tighten the saddle clamps

JOB SHEET #2

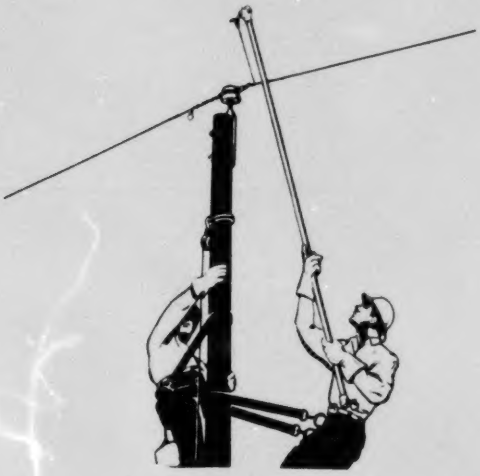
I. Wrap hot line tie onto conductor on the side opposite wire tong (Figure 7)

FIGURE 7



J. Remove wire tong and saddles and complete the hot line tie (Figure 8)

FIGURE 8



K. Replace the neutral

WORK PROCEDURES
(HOT LINE, BASKET, HOT STICK)
UNIT III

TEST

NAME ______________________________ SCORE ____________________

1. List two methods of hot line maintenance.

   a. ____

   b. ____

2. Select from the following list the OSHA requirements for aerial devices by placing an "X" in the blanks.

   _____a. Controls shall be plainly marked as to their functions

   _____b. Load limits may be exceeded if necessary

   _____c. Boom shall be cradled and outriggers shall be in the stowed position before moving vehicle

   _____d. Lift controls shall be tested each day prior to use

   _____e. Load limits of the equipment shall not be exceeded

   _____f. Only trained and authorized persons shall operate an aerial device

3. Select from the following list rules to observe when working with an aerial device by placing an "X" in the blanks.

   _____a. Climbers shall not be worn when working from an aerial device

   _____b. Rubber gloves and rubber sleeves must be worn while working energized primary from an aerial device

   _____c. Position the device so that no contact will be made between conductors or other equipment

   _____d. No person shall stand directly beneath the work area of an aerial device

   _____e. Safety hat and suitable clothing shall be worn when working with an aerial device

   _____f. Vehicle frame shall be grounded while the basket is in use near high voltage lines

   _____g. Climbers may be worn in a basket if the basket has a liner ______h. Assurance shall be made that the boom or basket is not in contact with an energized conductor before entering or leaving the vehicle

______i. A body belt with a securing strap shall be worn while working from an aerial basket

______j. Tools or equipment shall not be thrown to or from an aerial device

______k. The operator of the lower controls shall be on the vehicle or at the same potential as the vehicle

______l. Transfer to or from a structure and an aerial device shall not be allowed

______m. An aerial device shall be considered energized at line potential when the boom or basket is in close proximity to an energized conductor

4. List six elements of hot line maintenance.

a. ______________________________

b. ______________________________

c. ______________________________

d. ______________________________

e. ______________________________

f. ______________________________

5. State the procedure for hot line maintenance from an aerial device.

a. ______________________________

____

b. ______________________________

____

c. ______________________________

____

d. ______________________________

____

e. ____

____

f. ____

____

6. Arrange in the proper order the steps to follow when changing a pole top insulator from a basket.

_____a. Place line hose on the energized conductor near the insulator

_____b. Place warning signs at the work site

_____c. Untie the energized conductor

_____d. Move conductor back to insulator and retie

_____e. Ground the vehicle frame to the system neutral or a driven ground

_____f. Secure the energized conductor to an insulated attachment

_____g. Position basket truck near the pole

_____h. Elevate the basket to near the pole top and cover the pole top with a rubber blanket

_____i. Allow line technician on pole to change the insulator

_____j. Move conductor away from pole

_____k. Raise basket to neutral position and cover or lower the neutral

_____l. Clear the area near the vehicle and lower the outriggers

_____m. Check the outrigger footings for stability

_____n. Set the vehicle brakes and chock the wheels

7. Match the hot line tools on the right to their specific use.

_____a. Attaches to and holds conductor

_____b. Secures to pole and holds wire tong

_____c. Unties and ties conductor

_____d. Cuts energized conductor and tie wire

_____e. Holds conductor aside when pole is being relocated

_____f. Supports conductor while suspension insulators are being changed

_____g. Lowers and raises insulator string

_____h. Extends a pole to lay out conductor

_____i. Attachment point for rope blocks to raise and lower transformer

_____j. Holds conductors out of the way of repairs or is used to raise conductors above work area

_____k. Supports line technician near work area

_____l. Supports the line technician so the conductor may be reached with wire tong or other hot stick

_____m. Attaches to various tools which enable the line technician to tighten or remove clamps, connectors, bolts, and cotter keys

1. Wire cutter
2. Rural strain carrier
3. Pole gin
4. Universal platform
5. Wire tong saddle
6. Link stick
7. Auxiliary arm
8. Wire tong
9. Hook ladder
10. Tie stick
11. Insulator cradle
12. Transformer gin
13. Universal hot stick

8. Demonstrate the ability to:

a. Install a wire tong saddle.

b. Change an insulator on an energized conductor using hot line tools on an A1 structure.

(NOTE: If the above activities have not been accomplished prior to the test, ask the instructor when they should be completed.)

WORK PROCEDURES
(HOT LINE, BASKET, HOT STICK)
UNIT III

ANSWERS TO TEST

1. List two methods of hot line maintenance.

   a. Insulated aerial device

   b. Hot line tool

2. Select from the following list the OSHA requirements for aerial devices by placing an "X" in the blanks.

   ___X___ a. Controls shall be plainly marked as to their functions

   ______ b. Load limits may be exceeded if necessary

   ___X___ c. Boom shall be cradled and outriggers shall be in the stowed position before moving vehicle

   ___X___ d. Lift controls shall be tested each day prior to use

   ___X___ e. Load limits of the equipment shall not be exceeded

   ___X___ f. Only trained and authorized persons shall operate an aerial device

3. Select from the following list rules to observe when working with an aerial device by placing an "X" in the blanks.

   ___X___ a. Climbers shall not be worn when working from an aerial device

   ___X___ b. Rubber gloves and rubber sleeves must be worn while working energized primary from an aerial device

   ___X___ c. Position the device so that no contact will be made between conductors or other equipment

   ___X___ d. No person shall stand directly beneath the work area of an aerial device

   ___X___ e. Safety hat and suitable clothing shall be worn when working with an aerial device

   ___X___ f. Vehicle frame shall be grounded while the basket is in use near high voltage lines

   ______ g. Climbers may be worn in a basket if the basket has a liner

X h. Assurance shall be made that the boom or basket is not in contact with an energized conductor before entering or leaving the vehicle

X i. A body belt with a securing strap shall be worn while working from an aerial basket

X j. Tools or equipment shall not be thrown to or from an aerial device

X k. The operator of the lower controls shall be on the vehicle or at the same potential as the vehicle

X l. Transfer to or from a structure and an aerial device shall not be allowed

X m. An aerial device shall be considered energized at line potential when the boom or basket is in close proximity to an energized conductor

4. List six elements of hot line maintenance.

(NOTE: Any six of the following answers are acceptable.)

a. Replacing insulators

b. Replacing crossarms

c. Replacing poles

d. Installing armor rods

e. Splicing conductor

f. Cutting double dead end

g. Cutting slack in or out of conductor

h. Tapping a hot line

5. State the procedure for hot line maintenance from an aerial device.

a. Lower or cover the neutral and grounded parts

b. Work on only one conductor at a time

c. Cover and place energized conductors on insulated lifting attachments

d. Tension energized conductor with rope block or insulated hoist

e. Hang handline on structure not on basket

f. Install insulated jumper on conductor before opening a circuit

6. Arrange in the proper order the steps to follow when changing a pole top insulator from a basket.

9 a. Place line hose on the energized conductor near the insulator

1 b. Place warning signs at the work site

11 c. Untie the energized conductor

14 d. Move conductor back to insulator and retie

6 e. Ground the vehicle frame to the system neutral or a driven ground

10 f. Secure the energized conductor to an insulated attachment

2 g. Position basket truck near the pole

8 h. Elevate the basket to near the pole top and cover the pole top with a rubber blanket

13 i. Allow line technician on pole to change the insulator

12 j. Move conductor away from pole

7 k. Raise basket to neutral position and cover or lower the neutral

5 l. Clear the area near the vehicle and lower the outriggers

4 m. Check the outrigger footings for stability

3 n. Set the vehicle brakes and chock the wheels

7. Match the hot line tools on the right to their specific use.

 8 a. Attaches to and holds conductor

 5 b. Secures to pole and holds wire tong

 10 c. Unties and ties conductor

 1 d. Cuts energized conductor and tie wire

 6 e. Holds conductor aside when pole is being relocated

 2 f. Supports conductor while suspension insulators are being changed

 11 g. Lowers and raises insulator string

 3 h. Extends a pole to lay out conductor

 12 i. Attachment point for rope blocks to raise and lower transformer

 7 j. Holds conductors out of the way of repairs or is used to raise conductors above work area

 4 k. Supports line technician near work area

 9 l. Supports the line technician so the conductor may be reached with wire tong or other hot stick

 13 m. Attaches to various tools which enable the line technician to tighten or remove clamps, connectors, bolts, and cotter keys

1. Wire cutter
2. Rural strain carrier
3. Pole gin
4. Universal platform
5. Wire tong saddle
6. Link stick
7. Auxiliary arm
8. Wire tong
9. Hook ladder
10. Tie stick
11. Insulator cradle
12. Transformer gin
13. Universal hot stick

8. Demonstrate the ability to:

   a. Install a wire tong saddle.

   b. Change an insulator on an energized conductor using hot line tools on an A1 structure.

(NOTE: Performance skills will be evaluated to the satisfaction of the instructor.)

TROUBLESHOOTING
(SECONDARY)
UNIT IV

UNIT OBJECTIVE

After completion of this unit, the student should be able to safely follow a procedure for troubleshooting and match various malfunctions to their causes. This knowledge will be evidenced by scoring 85 percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms associated with troubleshooting to the correct definitions.
2. Match indications of malfunctions to the possible causes.
3. Arrange in order the correct procedure for troubleshooting electrical equipment.
4. List precautions to observe when troubleshooting electrical equipment.
5. Select from a list items of information which pertain to troubleshooting.

TROUBLESHOOTING
(SECONDARY)
UNIT IV

SUGGESTED ACTIVITIES

I. Suggested activities for the instructor:

   A. Provide student with objective sheet.

   B. Provide student with information sheet.

   C. Discuss unit and specific objectives.

   D. Discuss information sheet.

   E. Discuss troubleshooting problems you have encountered.

   F. Give test.

II. Unit reference--Kurtz, Edwin B., and Shoemaker, Thomas M. *The Lineman's and Cableman's Handbook.* 5th ed. New York: McGraw-Hill Book Co., 1976.

TROUBLESHOOTING
(SECONDARY)
UNIT IV

INFORMATION SHEET

I. Terms and definitions

A. Single phasing--Loss of power on one phase of a three-phase primary or secondary circuit

B. Voltage fluctuation--Extreme swing in voltage above and below voltage base

C. Common phases--Two phases that become energized from a single-phase source

D. Eddy current--Current induced in and around a transformer core or a conductor where it causes heating; current which flows contrary to the main current flow

E. Interlock--Electrical unit that prevents simultaneous operation of equipment

F. Operation--Function of a switch or circuit breaker

G. Relay--Electrically operated device that opens and closes a circuit

H. Trip--Function of a piece of equipment to open a circuit

II. Indications of malfunctions and possible causes

A. Low voltage

1. Transformer too small
2. Service conductor too small
3. Increased load on consumer's premises
4. Distance to power source too great
5. Voltage regulator inoperative
6. Line capacitors out of service

B. High voltage

1. Transformer tap set too high
2. Transformer winding damaged
3. Voltage regulator inoperative
4. High capacitance on primary line

INFORMATION SHEET

        5. Open neutral on secondary
        6. Open ground on transformer tank

    C. Blinking lights

        1. Poor connection at transformer
        2. Poor connection in meter base
        3. Improper connector on service wire
        4. Meter lugs burned or bent
        5. Trees in secondary or service

    D. Potential on water pipes or appliances

        1. Open neutral on secondary
        2. Grounds not interconnected
        3. Faulted motor winding
        4. Faulted fluorescent ballast
        5. Equipment or appliances not grounded

    E. Frequent service breaker tripping

        1. Breaker overloaded
        2. Poor connection at breaker terminals
        3. Breaker contacts burned
        4. Fault on circuit with high resistance to ground

III. Procedure for troubleshooting electrical equipment

    A. Obtain all information available pertaining to problem

    (NOTE: Check with other consumers to see if problem is on primary line.)

    B. Check voltage, amperage, transformer size, and service size

    C. Discuss findings with consumer

INFORMATION SHEET

D. Make repairs or corrections if problem is not on consumer's side of the meter

(NOTE: Some organizations do not make repairs or work on the consumer's side of the meter because of the liability involved when work is done on equipment not owned by the organization.)

E. Make report on findings and action taken

IV. Precautions to observe when troubleshooting electrical equipment

A. Wear protective equipment

B. Assume that conductors and equipment are energized

C. Use proper test equipment

V. Information pertaining to troubleshooting

A. Consumer's name

B. Consumer's location

C. Consumer's complaint

D. Number of consumers affected by problem

E. Time and date trouble began

F. Circumstances which might have caused problem

Examples: Wind, lightning, added load

TROUBLESHOOTING
(SECONDARY)
UNIT IV

TEST

NAME ______________________________ SCORE ________________

1. Match the terms on the right to the correct definitions.

______a. Loss of power on one phase of a three-phase primary or secondary circuit

______b. Extreme swing in voltage above and below voltage base

______c. Two phases that become energized from a single-phase source

______d. Current induced in and around a transformer core or a conductor where it causes heating; a current which flows contrary to the main current flow

______e. Electrical unit that prevents simultaneous operation of equipment

______f. Function of a switch or circuit breaker

______g. Electrically operated device that opens and closes a circuit

______h. Function of a piece of equipment to open a circuit

1. Eddy current
2. Relay
3. Interlock
4. Single phasing
5. Operation
6. Voltage fluctuation
7. Trip
8. Common phases

2. Match the indications of malfunctions on the right to the correct causes.

______a. Transformer too small; service conductor too small; increased load on consumer's premises; distance to power source too great; voltage regulator inoperative; line capacitors out of service

______b. Transformer tap set too high; transformer winding damaged; voltage regulator inoperative; high capacitance on primary line; open neutral on secondary; open ground on transformer tank

1. Blinking lights
2. High voltage
3. Potential on water pipes or appliances
4. Frequent service breaker tripping
5. Low voltage

______c. Poor connection at transformer; poor connection in meter base; improper connector on service wire; meter lugs burned or bent; trees in secondary or service

______d. Open neutral on secondary; grounds not interconnected; faulted motor winding; faulted fluorescent ballast; equipment or appliances not grounded

______e. Breaker overloaded; poor connection at breaker terminals; breaker contacts burned; fault on circuit with high resistance to ground

3. Arrange the following troubleshooting procedure in the proper order.

______a. Make repairs or corrections if problem is not on consumer's side of the meter

______b. Obtain all information available pertaining to the problem

______c. Make report on findings and action taken

______d. Discuss findings with consumer

______e. Check voltage, amperage, transformer size, and service size

4. List three precautions to observe when troubleshooting electrical equipment.

a. ______________________________

b. ______________________________

c. ______________________________

5. Select from the following list items of information which pertain to troubleshooting.

______a. Number of consumers affected by problem

______b. Consumer's name

______c. Time and date trouble began

______d. Consumer's location

______e. Size of consumer's dwelling

______f. Circumstances which might have caused problem

______g. Consumer's complaint

TROUBLESHOOTING
(SECONDARY)
UNIT IV

ANSWERS TO TEST

1. Match the terms on the right to the correct definitions.

   4 a. Loss of power on one phase of a three-phase primary or secondary circuit

   6 b. Extreme swing in voltage above and below voltage base

   8 c. Two phases that become energized from a single-phase source

   1 d. Current induced in and around a transformer core or a conductor where it causes heating; current which flows contrary to the main current flow

   3 e. Electrical unit that prevents simultaneous operation of equipment

   5 f. Function of a switch or circuit breaker

   2 g. Electrically operated device that opens and closes a circuit

   7 h. Function of a piece of equipment to open a circuit

   1. Eddy current
   2. Relay
   3. Interlock
   4. Single phasing
   5. Operation
   6. Voltage fluctuation
   7. Trip
   8. Common phases

2. Match the indications of malfunctions on the right to the correct causes.

   5 a. Transformer too small; service conductor too small; increased load on consumer's premises; distance to power source too great; voltage regulator inoperative; line capacitors out of service

   2 b. Transformer tap set too high; transformer winding damaged; voltage regulator inoperative; high capacitance on primary line; open neutral on secondary; open ground on transformer tank

   1. Blinking lights
   2. High voltage
   3. Potential on water pipes or appliances
   4. Frequent service breaker tripping
   5. Low voltage

__1__ c. Poor connection at transformer; poor connection in meter base; improper connector on service wire; meter lugs burned or bent; trees in secondary or service

__3__ d. Open neutral on secondary; grounds not interconnected; faulted motor winding; faulted fluorescent ballast; equipment or appliances not grounded

__4__ e. Breaker overloaded; poor connection at breaker terminals; breaker contacts burned; fault on circuit with high resistance to ground

3. Arrange the following troubleshooting procedure in the proper order.

__4__ a. Make repairs or corrections if problem is not on consumer's side of the meter

__1__ b. Obtain all information available pertaining to the problem

__5__ c. Make report on findings and action taken

__3__ d. Discuss findings with consumer

__2__ e. Check voltage, amperage, transformer size, and service size

4. List three precautions to observe when troubleshooting electrical equipment.

a. Wear protective equipment

b. Assume that conductors and equipment are energized

c. Use proper test equipment

5. Select from the following list items of information which pertain to troubleshooting.

__X__ a. Number of consumers affected by problem

__X__ b. Consumer's name

__X__ c. Time and date trouble began

__X__ d. Consumer's location

_____ e. Size of consumer's dwelling

__X__ f. Circumstances which might have caused problem

__X__ g. Consumer's complaint

TROUBLESHOOTING
(PRIMARY LINE)
UNIT I

UNIT OBJECTIVE

After completion of this unit, the student should be able to list problems which will be encountered while troubleshooting primary lines and match the problems to possible causes. The student should be able to list precautions to observe while troubleshooting and arrange in order the steps to shoot trouble. This knowledge will be evidenced by scoring 85 percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. List various problems which the troubleshooter may encounter.
2. Match various troubleshooting problems to possible causes.
3. Arrange in the correct order the troubleshooting procedures to follow for various problems.
4. List precautions to observe when troubleshooting primary lines.
5. Arrange in correct order the steps to follow when troubleshooting a primary line outage.

TROUBLESHOOTING
(PRIMARY LINE)
UNIT I

SUGGESTED ACTIVITIES

I. Suggested activities for instructor:

A. Provide student with objective sheet.

B. Provide student with information sheet.

C. Discuss unit and specific objectives.

D. Discuss information sheet.

E. Give test.

II. Unit references:

A. Kurtz, Edwin B., and Shoemaker, Thomas M. *The Lineman's and Cableman's Handbook*. 5th ed. New York: McGraw-Hill Book Co., 1976.

B. Rural Electrification Administration. *Location of Radio Interference on Rural Power Systems.* REA Bulletin 169-9. Washington, D.C.: U.S. Department of Agriculture, September 1950.

TROUBLESHOOTING
(PRIMARY LINE)
UNIT I

INFORMATION SHEET

I. Possible problems encountered by the troubleshooter

- A. Low line voltage
- B. High line voltage
- C. Blinking lights
- D. Extreme voltage swing
- E. Radio and television interference
- F. Line outage

II. Troubleshooting problems and possible causes

- A. Low line voltage
  - 1. Line overloaded
  - 2. Voltage regulator inoperative
  - 3. Capacitors not in operation
  - 4. Backfeed on open line from another source

    Example: Transformer bank or other utility
- B. High line voltage
  - 1. Voltage regulator inoperative
  - 2. Too much capacitance on the line
- C. Blinking lights
  - 1. Broken or burned connection
  - 2. Cattle rubbing down guy
  - 3. Trees blowing into line
  - 4. Contact with another line
  - 5. Swinging phase
  - 6. Broken insulator

INFORMATION SHEET

D. Extreme voltage swing
    1. Intermittent heavy load on line
    2. Oil field pumps not balanced
    3. Voltage regulator inoperative
    4. Open phase or phases in common

E. Radio and television interference
    1. Loose or burned connection
    2. Transformer breaking down
    3. Insulator breaking down
    4. Loose hardware
    5. Broken or loose pole ground
    6. Ground wire too close to hardware

F. Galvanic damage
    1. Pipeline rectifier set too high
    2. Poor ground condition
    3. High wattage radio station nearby
    4. Dissimilar metals underground

G. Line outage
    1. Small animal or bird on conductor
    2. Trees in line
    3. Cattle rubbing down guy
    4. Lightning
    5. Downed pole
    6. Broken insulator
    7. Lightning arrester shorted

INFORMATION SHEET

   8. Gap set too close on lightning arrester
   9. High wind blowing foreign objects into line
   10. Transformer faulted
   11. Breaker faulted
   12. Broken conductor

III. Troubleshooting procedures for specific problems

A. Low line voltage

   1. Measure line amperage
   2. Check conductor size
   3. Check voltage regulator
   4. Check line capacitors
   5. Check reclosers
   6. Record information

B. High line voltage

   1. Check voltage regulator
   2. Check line capacitors

      (NOTE: If line capacitors are operated by voltage, power factor, or thermal action, the operating device may have malfunctioned and failed to disconnect the capacitors from the line.)

C. Blinking lights

   1. Inspect line visually for loose or burned connections
   2. Check for tree in line
   3. Patrol line for signs of cattle rubbing down guys
   4. Check for swinging phase
   5. Set recording voltmeters along the line
   6. Check with consumers along the line to locate source of blinking

INFORMATION SHEET

D. Extreme voltage swing

1. Check for heavy intermittent load
2. Check for open phase or phases in common
3. Check for oil field or other types of unbalanced pumps
4. Check voltage regulator for proper operation

E. Radio and television interference

1. Check with consumers to find radius of interference
2. Use radio or noise locator to localize the source of interference
3. Check for loose connections
4. Disconnect transformer to see if interference source is on a secondary or in the transformer
5. Check fence chargers in the area

F. Line outage

1. Locate consumer on your system map
2. Trace phase to which consumer is connected to breaker or fuse which protects that phase
3. Reset the breaker or re-fuse the line

IV. Precautions to observe when troubleshooting prprimary lines

(NOTE: Troubleshooting requires a constant vigilance for the probability of unknown hazards. Every safety precaution should be observed at all times.)

A. Assume all conductors are energized unless grounds are installed within sight

(NOTE: Telephone lines or fences may be energized from a downed phase.)

B. Do not place yourself in series with an open neutral or ground

C. Wear your personal protective equipment

(NOTE: Rubber gloves, hard hat, and eye protection are especially important when troubleshooting because of the possibility of unknown hazards.)

D. Place hold card at disconnect point

INFORMATION SHEET

V. Steps to troubleshoot a primary line outage

  A. Reset the open breaker

  (NOTE: A preliminary check of the faulted line may determine the cause before resetting the breaker.)

  B. Patrol line to mid-point between open breaker and the end of the line if the fault remains on the line

  C. Open line at mid-point if the fault is not located

  (NOTE: The line should be opened as near as possible to mid-point or at the next connection or switch.)

  D. Return to open breaker and reset it

  (NOTE: If breaker holds, the fault is between the opening and the end of the line. If the breaker does not hold, the fault is between the open breaker and the opening in the line.)

  E. Disconnect transformers and taps in the section of line that is faulted

  F. Reconnect line at mid-point with a temporary fuse holder

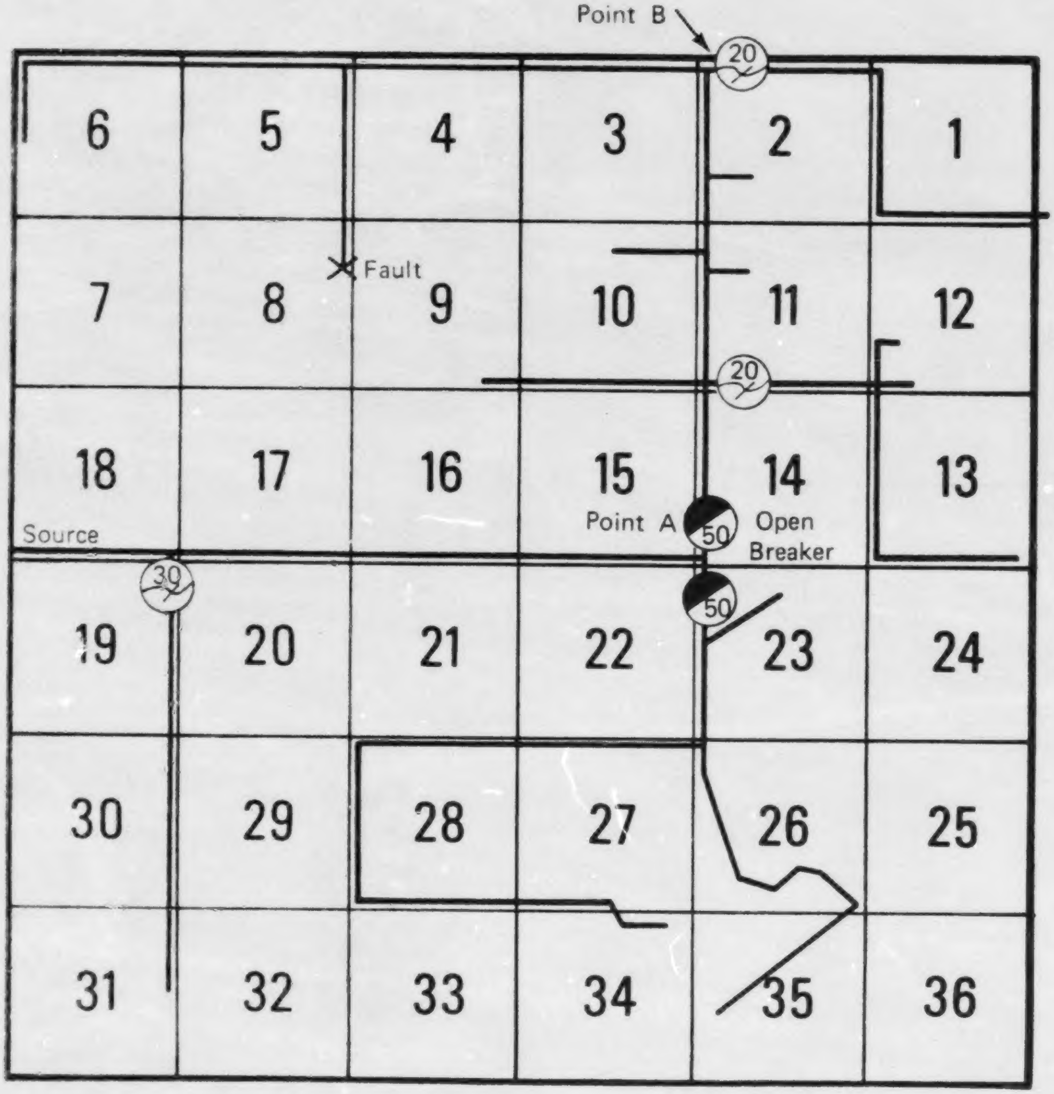
  G. Reconnect transformers and taps with a temporary fuse holder between the transformer or tap and the line

  (NOTE: If fuse does not blow, reconnect transformer to the line.)

  Example: Troubleshooting a primary line outage which occurs at Point "A"

    1. Reset breaker at Point "A"
    2. Patrol line to Point "B" if breaker does not hold
    3. Open the line at Point "B" if fault is not located
    4. Reset breaker at Point "A"
    5. Patrol line from Point "B" to end of line
    6. Locate fault, install protective grounds, and repair fault

INFORMATION SHEET



TROUBLESHOOTING
(PRIMARY LINE)
UNIT I

TEST

NAME ______________________________ SCORE ________________

1. List five problems the troubleshooter may encounter on a primary line.

   a. ____

   b. ____

   c. ____

   d. ____

   e. ____

2. Match the troubleshooting problems on the right to the possible causes.

   _____a. Line overloaded; voltage regulator inoperative; capacitors not in operation; backfeed on open line from another source

   _____b. Voltage regulator inoperative; too much capacitance on the line

   _____c. Broken or burned connection; cattle rubbing down guy; trees blowing into line; contact with another line; swinging phase; broken insulator

   _____d. Intermittent heavy load on line; oil field pumps not balanced; voltage regulator inoperative; open phase or phases in common

   _____e. Loose or burned connection; transformer breaking down; insulator breaking down; loose hardware; broken or loose pole ground; ground wire too close to hardware

   _____f. Pipeline rectifier set too high; poor ground condition; high wattage radio station nearby; dissimilar metals underground

   1. Blinking lights
   2. Galvanic damage
   3. Extreme voltage swing
   4. Line outage
   5. Radio and television interference
   6. Low line voltage
   7. High line voltage

_____g. Small animal or bird on conductor; trees in line; cattle rubbing down guy; lightning; downed pole; broken insulator; lightning arrester shorted; gap set too close on lightning arrester; high wind blowing foreign objects into line; transformer faulted; breaker faulted; broken conductor

3. Arrange in the correct order the troubleshooting procedures to follow for the problems below.

a. Low line voltage

_____ Check line capacitors

_____ Record information

_____ Check voltage regulator

_____ Measure line amperage

_____ Check conductor size

_____ Check reclosers

b. Blinking lights

_____ Check with consumers along the line to locate source of blinking

_____ Check for trees in the line

_____ Inspect line visually for loose or burned connections

_____ Set recording voltmeters along the line

_____ Check for swinging phase

_____ Patrol line for signs of cattle rubbing down guys

c. Extreme voltage swing

_____ Check for open phase or phases in common

_____ Check for heavy intermittent load

_____ Check voltage regulator for proper operation

_____ Check for oil field or other types of unbalanced pumps

d. Line outage

_____ Reset the breaker or re-fuse the line

_____ Locate consumer on your system map

_____ Trace phase to which consumer is connected to breaker or fuse which protects that phase

e. Radio and television interference

_____ Check with consumers to find radius of interference

_____ Check fence chargers in the area

_____ Check for loose connections

_____ Use radio or noise locator to localize the source of interference

_____ Disconnect transformer to see if interference source is on a secondary or in the transformer

f. High line voltage

_____ Check line capacitors

_____ Check voltage regulator

4. List four precautions to observe when troubleshooting primary lines.

a. ____

____

b. ____

____

c. ____

____

d. ____

____

5. Arrange in the correct order the steps to follow when troubleshooting a primary line outage.

______a. Disconnect transformers and taps in the section of line that is faulted

______b. Reset the open breaker

______c. Reconnect line at mid-point with a temporary fuse holder

______d. Return to open breaker and reset it

______e. Open line at mid-point if the fault is not located

______f. Reconnect transformers and taps with a temporary fuse holder between the transformer or tap and the line

______g. Patrol line to mid-point between open breaker and the end of the line if the fault remains on the line

TROUBLESHOOTING
(PRIMARY LINE)
UNIT I

ANSWERS TO TEST

1. List five problems the troubleshooter may encounter on a primary line.

   (NOTE: Any five of the following answers are acceptable.)

   a. Low line voltage
   b. High line voltage
   c. Blinking lights
   d. Extreme voltage swing
   e. Radio and television interference
   f. Line outage

2. Match the troubleshooting problems on the right to the possible causes.

   _6_ a. Line overloaded; voltage regulator inoperative; capacitors not in operation; backfeed on open line from another source

   _7_ b. Voltage regulator inoperative; too much capacitance on the line

   _1_ c. Broken or burned connection; cattle rubbing down guy; trees blowing into line; contact with another line; swinging phase; broken insulator

   _3_ d. Intermittent heavy load on line; oil field pumps not balanced; voltage regulator inoperative; open phase or phases in common

   _5_ e. Loose or burned connection; transformer breaking down; insulator breaking down; loose hardware; broken or loose pole ground; ground wire too close to hardware

   _2_ f. Pipeline rectifier set too high; poor ground condition; high wattage radio station nearby; dissimilar metals underground

   1. Blinking lights
   2. Galvanic damage
   3. Extreme voltage swing
   4. Line outage
   5. Radio and television interference
   6. Low line voltage
   7. High line voltage

4 g. Small animal or bird on conductor; trees in line; cattle rubbing down guy; lightning; downed pole; broken insulator; lightning arrester shorted; gap set too close on lightning arrester; high wind blowing foreign objects into line; transformer faulted; breaker faulted; broken conductor

3. Arrange in the correct order the troubleshooting procedures to follow for the problems below.

a. Low line voltage

4 Check line capacitors

6 Record information

3 Check voltage regulator

1 Measure line amperage

2 Check conductor size

5 Check reclosers

b. Blinking lights

6 Check with consumers along the line to locate source of blinking

2 Check for trees in the line

1 Inspect line visually for loose or burned connections

5 Set recording voltmeters along the line

4 Check for swinging phase

3 Patrol line for signs of cattle rubbing down guys

c. Extreme voltage swing

2 Check for open phase or phases in common

1 Check for heavy intermittent load

4 Check voltage regulator for proper operation

3 Check for oil field or other types of unbalanced pumps

d. Line outage

3 Reset the breaker or re-fuse the line

1 Locate consumer on your system map

2 Trace phase to which consumer is connected to breaker or fuse which protects that phase

e. Radio and television interference

1 Check with consumers to find radius of interference

5 Check fence chargers in the area

3 Check for loose connections

2 Use radio or noise locator to localize the source of interference

4 Disconnect transformer to see if interference source is on a secondary or in the transformer

f. High line voltage

2 Check line capacitors

1 Check voltage regulator

4. List four precautions to observe when troubleshooting primary lines.

a. Assume all conductors are energized unless grounds are installed within sight

b. Do not place yourself in series with an open neutral or ground

c. Wear your personal protective equipment

d. Place hold card at disconnect point

5. Arrange in the correct order the steps to follow when troubleshooting a primary line outage.

5 a. Disconnect transformers and taps in the section of line that is faulted

1 b. Reset the open breaker

6 c. Reconnect line at mid-point with a temporary fuse holder

4 d. Return to open breaker and reset it

3 e. Open line at mid-point if the fault is not located

7 f. Reconnect transformers and taps with a temporary fuse holder between the transformer or tap and the line

2 g. Patrol line to mid-point between open breaker and the end of the line if the fault remains on the line

SYSTEM KNOWLEDGE
(PHASE II)
UNIT II

UNIT OBJECTIVE

After completion of this unit, the student should be able to list problems which can be caused by line switching and be able to follow the steps to switch line. The student should be able to list precautions to observe with line switching and voltage regulators on switched line. The student should be able to select from a list the areas and locations of importance to the line technician. This knowledge will be evidenced by scoring 85 percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. List problems associated with line switching.
2. Arrange in the correct order steps to follow when switching line.
3. List factors involved in line switching.
4. Select from a list precautions to observe with line voltage regulators on a switched line.
5. List precautions to observe when opening a line switch.
6. Select from a list areas and locations of importance to the line technician.

SYSTEM KNOWLEDGE
(PHASE II)
UNIT II

SUGGESTED ACTIVITIES

I. Suggested activities for the instructor:

   A. Provide student with objective sheet.

   B. Provide student with information sheet.

   C. Discuss unit and specific objectives.

   D. Discuss information sheet.

   E. Show student local cooperative area map.

   F. Discuss substation locations and feeds.

   G. Discuss line feeds and possible switching location.

   H. Give test.

II. Unit references:

   A. Rural Electrification Administration. *Guide for Mapping and Location Numbering: Electric Distribution Systems.* REA Bulletin 40-4. Washington, D.C.: U.S. Department of Agriculture, 1963.

   B. Rural Electrification Administration. *Voltage Regulator Application on Rural Distribution Systems.* REA Bulletin 169-27. Washington, D.C.: U.S. Department of Agriculture, 1973.

SYSTEM KNOWLEDGE
(PHASE II)
UNIT II

INFORMATION SHEET

I. Problems associated with line switching

  A. Low line voltage

  B. High line voltage

  C. Line outage

  D. Breaker operation

  E. Equipment failure

II. Steps to follow when switching line

  (NOTE: If a large amount of line is to be switched, the power supplier should be notified.)

  A. Check amperage on the line to be switched

  B. Check amperage on the line which is to carry the additional load

  C. Check breaker size on the line to which additional load is to be added

    (NOTE: If the circuit which is to carry the additional load is already loaded, an alternate method should be considered.)

  D. Phase the circuits together that are to be connected

  E. Notify the dispatcher of the location and amount of line to be switched

  F. Receive clearance from dispatcher

  G. Connect circuits together

  H. Open switched line at opposite end of circuit

III. Factors involved in line switching

  A. Line voltage regulation

  B. Capacitors on the line

  C. Three-phase transformer banks

INFORMATION SHEET

- D. Number of consumers on the line
- E. Length of line to be switched
- F. Overcurrent protection size

  Examples: OCR, sectionalizer, fuse

IV. Precautions to observe with line voltage regulators on switched line

(NOTE: The three precautions listed are alternatives and only one is to be used.)

- A. Disconnect the regulator from the circuit
- B. Set and lock the regulator in the Neutral position
- C. Reconnect the regulator for reverse power flow

V. List precautions to observe when opening a line switch

- A. Wear eye and head protection
- B. Check the blades visually to see that they are open
- C. Lock the switch handle open and place hold card
- D. Close the switch immediately if the arc does not extinguish itself

VI. Areas and locations of importance to the line technician

- A. Substation locations
- B. Substation areas of feed
- C. Line regulator locations
- D. Capacitor locations
- E. Oil circuit recloser locations and sizes
- F. Sectionalizer locations and sizes
- G. Line fuse locations and sizes
- H. Line switch locations
- I. Locations of emergency loads
- J. Locations of dual feeds

SYSTEM KNOWLEDGE
(PHASE II)
UNIT II

TEST

NAME ______________________________ SCORE ____________

1. List five problems associated with line switching.

a. ____

b. ____

c. ____

d. ____

e. ____

2. Arrange in the correct order the steps to follow when switching line.

_____a. Phase the circuits together that are to be connected

_____b. Check amperage on the line which is to carry the additional load

_____c. Receive clearance from dispatcher

_____d. Check amperage on the line to be switched

_____e. Check breaker size on the line to which the additional load is to be added

_____f. Connect circuits together

_____g. Open switched line at opposite end of circuit

_____h. Notify the dispatcher of the location and amount of line to be switched

3. List five factors involved in line switching.

a. ____

b. ____

c. ____

d. ____

e. ____

4. Select from the following list precautions to observe with line voltage regulators on a switched line.

_____a. Set and lock the regulator in the Neutral position

_____b. Disregard the regulator operation

_____c. Reconnect the regulator for reverse power flow

_____d. Disconnect the regulator from the circuit

5. List four precautions to observe when opening a line switch.

a. ______________________________

b. ______________________________

c. ______________________________

d. ______________________________

6. Select from the following list areas and locations of importance to the line technician.

_____a. Oil circuit recloser locations and sizes

_____b. Substation locations

_____c. Sectionalizer locations and sizes

_____d. Pole sizes

_____e. Capacitor locations

_____f. Substation areas of feed

_____g. Line fuse locations and sizes

_____h. Line regulator locations

_____i. Line switch locations

_____j. Locations of emergency loads

_____k. Locations of dual feeds

SYSTEM KNOWLEDGE
(PHASE II)
UNIT II

ANSWERS TO TEST

1. List five problems associated with line switching.

   a. Low line voltage

   b. High line voltage

   c. Line outage

   d. Breaker operation

   e. Equipment failure

2. Arrange in the correct order the steps to follow when switching line.

   4 a. Phase the circuits together that are to be connected

   2 b. Check amperage on the line which is to carry the additional load

   6 c. Receive clearance from dispatcher

   1 d. Check amperage on the line to be switched

   3 e. Check breaker size on the line to which additional load is to be added

   7 f. Connect circuits together

   8 g. Open switched line at opposite end of circuit

   5 h. Notify the dispatcher of the location and amount of line to be switched

3. List five factors involved in line switching.

   (NOTE: Any five of the following answers are acceptable.)

   a. Line voltage regulation

   b. Capacitors on the line

   c. Three-phase transformer banks

   d. Number of consumers on the line

   e. Length of line to be switched

   f. Overcurrent protection size

4. Select from the following list precautions to observe with line voltage regulators on a switched line.

 X a. Set and lock the regulator in the Neutral position

____ b. Disregard the regulator operation

 X c. Reconnect the regulator for reverse power flow

 X d. Disconnect the regulator from the circuit

5. List four precautions to observe when opening a line switch.

a. Wear eye and head protection

b. Check the blades visually to see that they are open

c. Lock the switch handle open and place hold card

d. Close the switch immediately if the arc does not extinguish itself

6. Select from the following list areas and locations of importance to the line technician.

 X a. Oil circuit recloser locations and sizes

 X b. Substation locations

 X c. Sectionalizer locations and sizes

____ d. Pole sizes

 X e. Capacitor locations

 X f. Substation areas of feed

 X g. Line fuse locations and sizes

 X h. Line regulator locations

 X i. Line switch locations

 X j. Locations of emergency loads

 X k. Locations of dual feeds

CONVERSIONS
UNIT III

UNIT OBJECTIVE

After completion of this unit, the student should be able to arrange in order the steps to safely convert a primary line to additional phases or a higher voltage. This knowledge will be evidenced by scoring 85 percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. List types of conversions.
2. Arrange in the correct order steps to convert a primary line to a higher voltage.
3. Arrange in the correct order steps to change a substation feed area to a higher voltage.
4. List benefits of converting to a higher voltage.
5. Select from a list precautions to observe with autotransformers.
6. Arrange in the correct order steps to convert a single-phase line to V-phase.
7. Arrange in the correct order steps to convert a single-phase line to three-phase.

CONVERSIONS
UNIT III

SUGGESTED ACTIVITIES

I. Suggested activities for instructor:

   A. Provide student with objective sheet.

   B. Provide student with information sheet.

   C. Make transparency.

   D. Discuss unit and specific objectives.

   E. Discuss information sheet.

   F. Show films and other supplemental materials on conversion.

   G. Give test.

II. Unit reference--Kurtz, Edwin B., and Shoemaker, Thomas M. *The Lineman's and Cableman's Handbook.* 5th ed. New York: McGraw-Hill Book Co., 1976.

CONVERSIONS
UNIT III

INFORMATION SHEET

I. Types of conversions

   A. Single-phase to V-phase

   B. Single-phase to three-phase

   C. V-phase to three-phase

   D. Conversion to a higher voltage

   E. Conversion to a larger conductor

II. Steps to convert a primary line to a higher voltage (7,200 to 14,400 volts)

   A. Change all insulators to a higher voltage insulator

   B. Change lightning arresters to a higher flashover level (18 kV)

   C. Install auto or two-winding transformer at the point where conversion is to start

   D. Disconnect all transformers on the line to be converted

   E. Connect the auto or two-winding transformer to feed the converted line with the higher voltage

   F. Change all transformers on the converted line to the higher voltage transformer

   (NOTE: The preceding method is used to convert a line from the end of the line back to the substation.)

III. Steps to convert a substation feed area to a higher voltage

   A. Reinsulate all poles in the substation feed area to 14,400-volt insulation

   B. Install auto or two-winding transformers on each phase at the substation

   C. Convert the substation to the higher voltage (14,400 volts)

   (NOTE: The power transformer, voltage regulator, lightning arresters, and oil circuit reclosers must be changed to meet the higher voltage requirements.)

   D. Disconnect all distribution circuits at the substation

INFORMATION SHEET

E. Connect the auto or two-winding transformers to transform 14,400 volts to 7,200 volts

F. Reconnect all distribution circuits at the substation

G. Install auto or two-winding transformers a short way from the substation on the circuit to be converted (14,400 to 7,200)

H. Disconnect all transformers on the circuit being converted

I. Disconnect the autotransformers at the substation on the circuit being converted

J. Energize the circuit being converted at the substation with 14,400 volts

K. Change all transformers on the circuit being converted to 14,400-volt transformers and connect to the line

L. Remove the autotransformers at the substation that were feeding the converted circuit

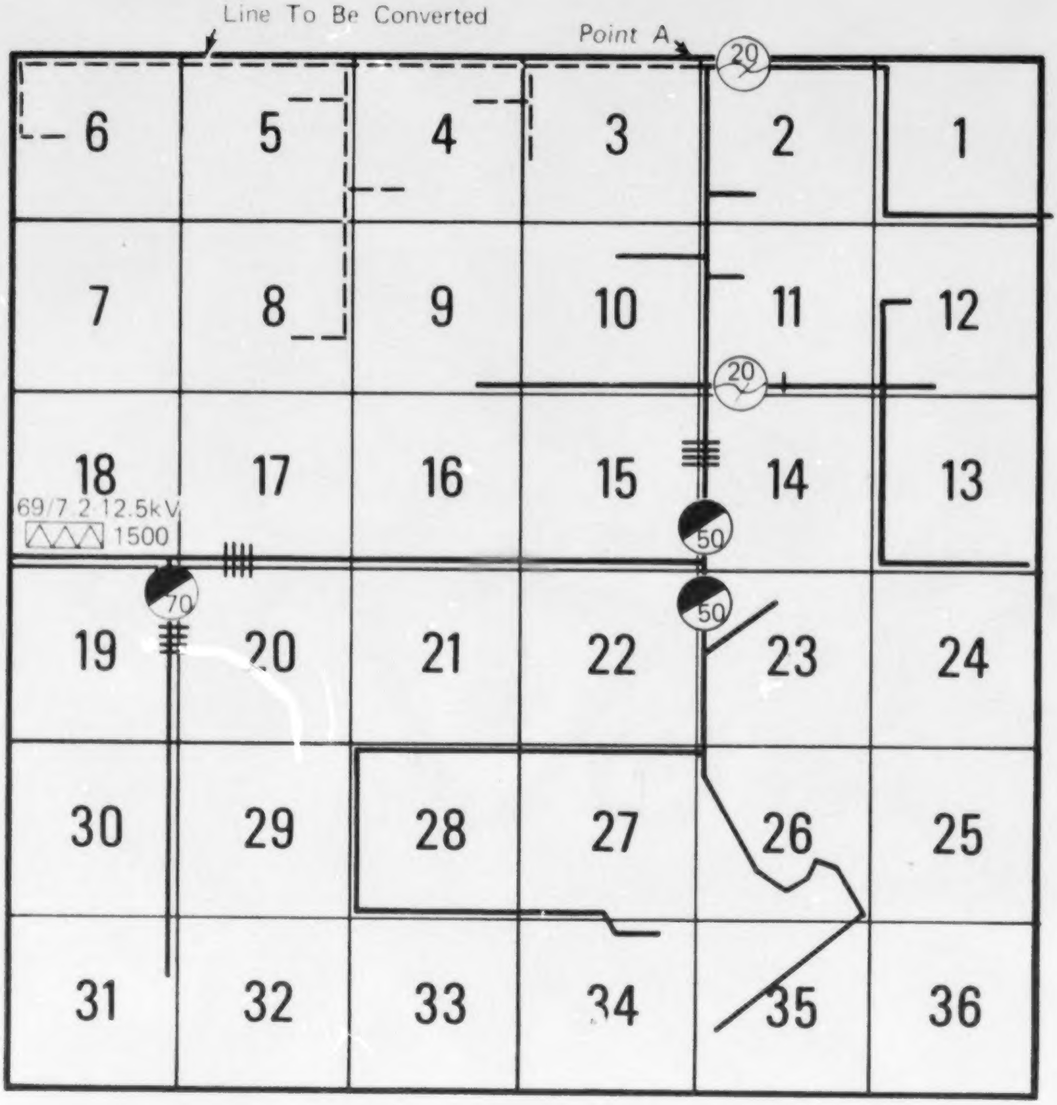
M. Move the disconnected autotransformers to a point beyond the autotransformers on the converted circuit and convert the section of line between the autotransformers

Example:

1. Reinsulate all poles in section of line to be converted
2. Install 333 KVA autotransformers at Point "A"
3. Disconnect all transformers in section of line to be converted
4. Connect autotransformer at Point "A" to feed line being converted with 14.4 kV
5. Change all transformers in section being converted to 14.4 kV transformers and connect newly installed transformers to the line as they are installed

(NOTE: Refer to the illustration on the following page.)

INFORMATION SHEET



(NOTE: The alternate method of line voltage conversion is more expensive because more auto or two-winding transformers are required. However, the alternate method may be required due to the timing of the substation change and the time required to reinsulate the entire feed area of a substation.)

IV. Benefits of converting to a higher voltage

A. Line amperage is reduced to one-half of the original amperage when the voltage is doubled

INFORMATION SHEET

B. *Line voltage drop is reduced*

C. Voltage conversion may be accomplished without changing the conductor

D. Smaller conductor may be used

V. Precautions to observe with autotransformers (Transparency 1)

A. Install with overvoltage protection

B. Install with overcurrent protection

C. Limit the fault current through an autotransformer to 25 times its rated current

D. Limit voltage transformation to no greater than three to one

E. Connect the neutral bushing solidly to the system neutral

(CAUTION: Autotransformer will transform voltage in either direction. Care should be taken to connect the autotransformer so that the desired voltage will be fed to the correct conductor.)

VI. Steps to convert a single-phase line to V-phase

A. Check all poles for soundness

B. Check all right-of-ways for adequate clearance

C. Install crossarms with hardware for the additional phase

D. Lower neutral four feet on all vertical corners and angle poles

E. Add down guy to dead end and vertical angle pole

F. String conductor for additional phase

G. Sag and tie in the conductor on the crossarm

VII. Steps to convert a single-phase line to three-phase

A. Check all poles for size and soundness

B. Check all right-of-ways for adequate clearance

C. Install crossarms with hardware on each end for the additional phases

INFORMATION SHEET

D. Lower neutral eight feet on all vertical corners and vertical angles

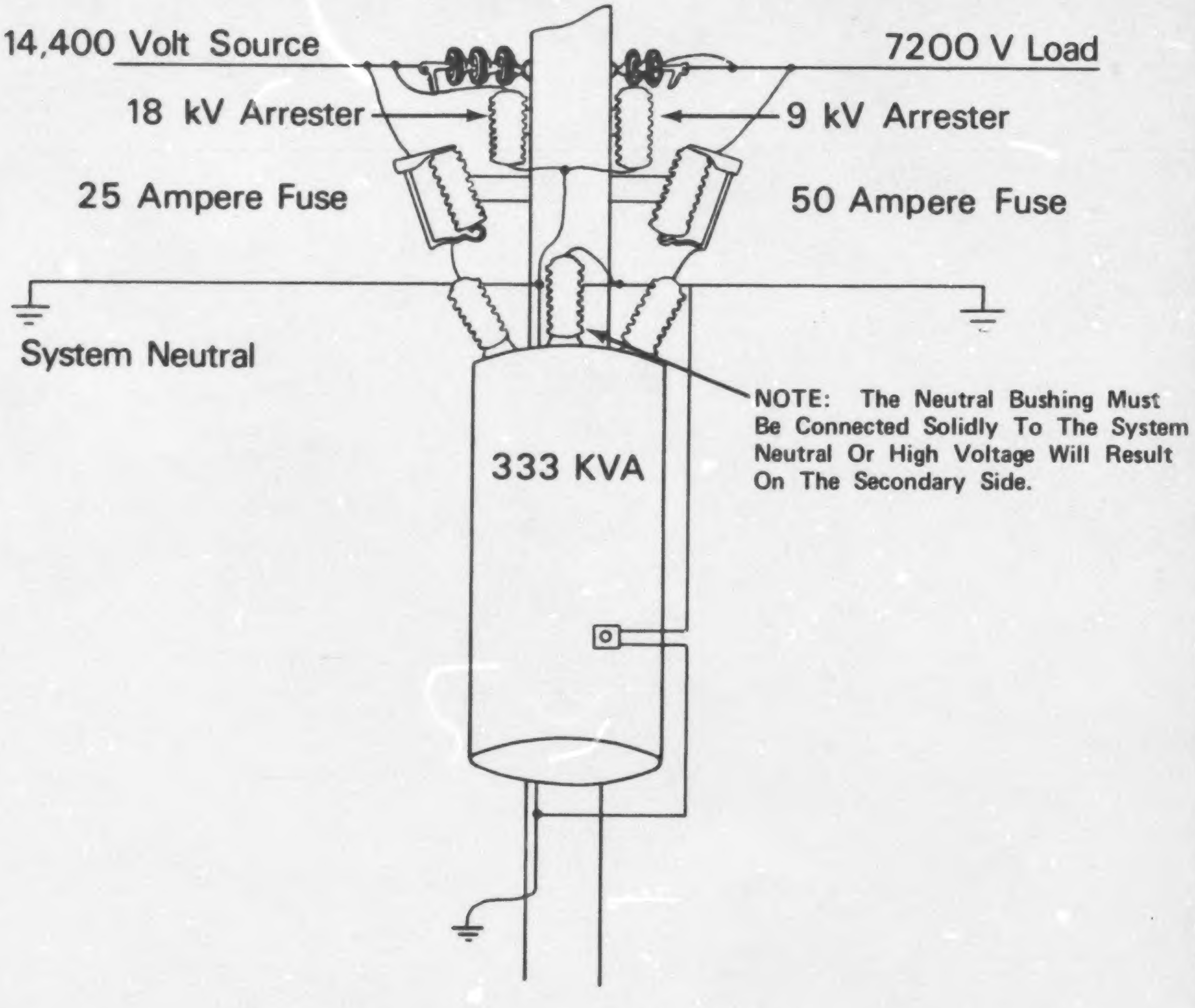
E. Add additional down guys to all dead ends and vertical angle poles

F. String conductors for the additional phases

G. Pull the additional conductors to sag and tie in on the crossarms

(CAUTION: Pulling in a conductor on a pole with an energized conductor should be done with a controlled tension wire stringing reel. The wire stringing reel and the truck or trailer that it is mounted on must be grounded. Attach a running ground to conductor being pulled in.)

Autotransformer Protection



NOTE: The Neutral Bushing Must Be Connected Solidly To The System Neutral Or High Voltage Will Result On The Secondary Side.

CONVERSIONS
UNIT III

TEST

NAME ______________________________ SCORE ________________

1. List five types of conversions.

   a. ____

   b. ____

   c. ____

   d. ____

   e. ____

2. Arrange in the correct order the following steps to convert a primary line to a higher voltage.

   _____a. Connect the auto or two-winding transformer to feed the converted line with the higher voltage

   _____b. Change all transformers on the converted line to the higher voltage transformer

   _____c. Disconnect all transformers on the line to be converted

   _____d. Install auto or two-winding transformer at the point where conversion is to start

   _____e. Change lightning arresters to a higher flashover level (18 kV)

   _____f. Change all insulators to a higher voltage insulator

3. Arrange in the correct order the following steps to convert a substation feed area to a higher voltage. (Steps are continued on the following page.)

   _____a. Convert the substation to the higher voltage (14,400 V)

   _____b. Disconnect all distribution circuits at the substation

   _____c. Change all transformers on the circuit being converted to 14,400-volt transformers and connect to the line

   _____d. Energize the circuit being converted at the substation with 14,400 volts

   _____e. Disconnect all transformers on the circuit being converted

   _____f. Connect the auto or two-winding transformers to transform 14,400 volts to 7,200 volts ______g. Install auto or two-winding transformers on each phase at the substation

______h. Reconnect all distribution circuits at the substation

______i. Install auto or two-winding transformers a short way from the substation on the circuit to be converted (14,400 to 7,200 volts)

______j. Remove the autotransformers at the substation that were feeding the converted circuit

______k. Reinsulate all poles in the substation feed area to 14,400-volt insulation

______l. Move the disconnected autotransformers to a point beyond the autotransformers on the converted circuit and convert the section of line between the autotransformers

______m. Disconnect the autotransformers at the substation on the circuit being converted

4. List four benefits of converting to a higher voltage.

a. ______________________________

____

____

b. ______________________________

____

____

c. ______________________________

____

____

d. ______________________________

____

____

5. Select from the following list precautions to observe with autotransformers by placing an "X" in the blanks.

______a. Connect the neutral bushing solidly to the system neutral

______b. Limit voltage transformation to no greater than three to one

______c. Install with line drop compensator set at four

______d. Install with overcurrent protection

______e. Install with overvoltage protection

______f. Limit the fault current through an autotransformer to 25 times its rated current

6. Arrange in the correct order the following steps to convert a single-phase line to V-phase.

______a. Install crossarms with hardware for the additional phase

______b. Add down guy to dead end and vertical angle pole

______c. Check all right-of-ways for adequate clearance

______d. String conductor for additional phase

______e. Check all poles for soundness

______f. Lower neutral four feet on all vertical corners and angle poles

______g. Sag and tie in the conductor on the crossarm

7. Arrange in the correct order the following steps to convert a single-phase line to three-phase.

______a. Lower neutral eight feet on all vertical corners and vertical angles

______b. Check all poles for size and soundness

______c. Add additional down guys to all dead ends and vertical angle poles

______d. Install crossarms with hardware on each end for the additional phases

______e. Check all right-of-ways for adequate clearance

______f. String conductors for the additional phases

______g. Pull the additional conductors to sag and tie in on the crossarms

CONVERSIONS
UNIT III

ANSWERS TO TEST

1. List five types of conversions.

   a. Single-phase to V-phase

   b. Single-phase to three-phase

   c. V-phase to three-phase

   d. Conversion to a higher voltage

   e. Conversion to a larger conductor

2. Arrange in the correct order the following steps to convert a primary line to a higher voltage.

   5 a. Connect the auto or two-winding transformer to feed the converted line with the higher voltage

   6 b. Change all transformers on the converted line to the higher voltage transformer

   4 c. Disconnect all transformers on the line to be converted

   3 d. Install auto or two-winding transformer at the point where conversion is to start

   2 e. Change lightning arresters to a higher flashover level (18 kV)

   1 f. Change all insulators to a higher voltage insulator

3. Arrange in the correct order the following steps to convert a substation feed area to a higher voltage.

   3 a. Convert the substation to the higher voltage (14,400 V)

   4 b. Disconnect all distribution circuits at the substation

   11 c. Change all transformers on the circuit being converted to 14,400-volt transformers and connect to the line

   10 d. Energize the circuit being converted at the substation with 14,400 volts

   8 e. Disconnect all transformers on the circuit being converted

   5 f. Connect the auto or two-winding transformers to transform 14,400 volts to 7,200 volts

   2 g. Install auto or two-winding transformers on each phase at the substation

6 h. Reconnect all distribution circuits at the substation

7 i. Install auto or two-winding transformers a short way from the substation on the circuit to be converted (14,400 to 7,200 volts)

12 j. Remove the autotransformers at the substation that were feeding the converted circuit

1 k. Reinsulate all poles in the substation feed area to 14,400-volt insulation

13 l. Move the disconnected autotransformers to a point beyond the autotransformers on the converted circuit and convert the section of line between the autotransformers

9 m. Disconnect the autotransformers at the substation on the circuit being converted

4. List four benefits of converting to a higher voltage.

a. Line amperage is reduced to one-half of the original amperage when the voltage is doubled

b. Line voltage drop is reduced

c. Voltage conversion may be accomplished without changing the conductor

d. Smaller conductor may be used

5. Select from the following list precautions to observe with autotransformers by placing an "X" in the blanks.

X a. Connect the neutral bushing solidly to the system neutral

X b. Limit voltage transformation to no greater than three to one

c. Install with line drop compensator set at four

X d. Install with overcurrent protection

X e. Install with overvoltage protection

X f. Limit the fault current through an autotransformer to 25 times its rated current

6. Arrange in the correct order the following steps to convert a single-phase line to V-phase.

3 a. Install crossarms with hardware for the additional phase

5 b. Add down guy to dead end and vertical angle pole

2 c. Check all right-of-ways for adequate clearance

6 d. String conductor for additional phase

__1__ e. Check all poles for soundness

__4__ f. Lower neutral four feet on all vertical corners and angle poles

__7__ g. Sag and tie in the conductor on the crossarm

7. Arrange in the correct order the following steps to convert a single-phase line to three-phase.

__4__ a. Lower neutral eight feet on all vertical corners and vertical angles

__1__ b. Check all poles for size and soundness

__5__ c. Add additional down guys to all dead ends and vertical angle poles

__3__ d. Install crossarms with hardware on each end for the additional phases

__2__ e. Check all right-of-ways for adequate clearance

__6__ f. String conductors for the additional phases

__7__ g. Pull the additional conductors to sag and tie in on the crossarms